Highlights of Natural Resources Management 1990

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National Park Service

Highlights of Natural Resources Management

A Report on National Park Service Natural Resources Management Activities in 1990

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Edited by Lissa Fox

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Table of Contents

Introduction

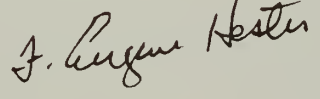
As we approach the end of the century, environmental trends and conditions signal a new era of challenges for managing the natural resources of the National Park System. Every day, more of the nation's natural habitat is lost, species diversity reduced, and air and water contaminated. Our national parks continue to take on increasingly important roles in the preservation of our natural heritage.

The National Park System contains many of the least disturbed sites in the country. Parks that are least changed by man are outstanding places to study how natural processes work and how they change as we alter the larger ecosystem around them. Our parks also provide some of the best areas to foster natural diversity and some of the last areas to support certain threatened and endangered species. The national parks protect many of our nation's remaining natural treasures, saving them for the enjoyment of future generations. The challenge to the Park Service to preserve these resources is difficult, but extremely vital.

Natural resources loomed large in the issues confronting the National Park Service in 1990. The Service faced problems such as visibility degradation at Grand Canyon and Shenandoah National Parks, a lawsuit on water quality degradation at Everglades, and conflicts between Yellowstone bison management objectives and adjacent grazing interests.

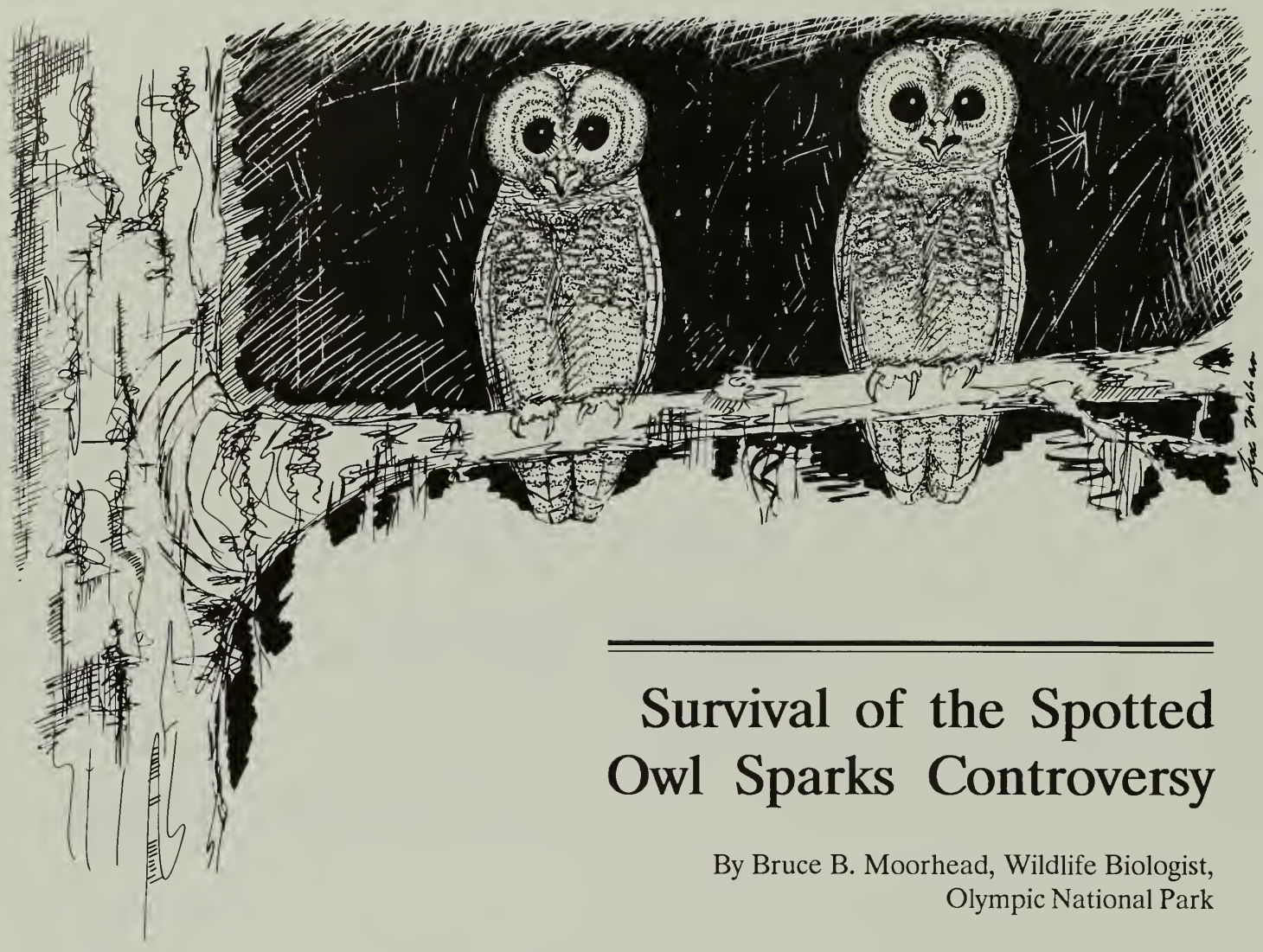
More importantly, 1990 saw several significant steps to equip us for the new decade of resource management. In April 1990, a task force was established to design a comprehensive and systematic inventory and monitoring program for the National Park Service. The group completed the groundwork for an ambitious program. A foundation was also laid for Park Service participation in global change research. This research effort followed National Park Service participation in a 10-year effort to study acid rain. As pointed out by author Jill Baron in one of the following articles, this experience brought the Park Service into a national level, multi-agency, multi-university research effort, showing us the benefits to be gained from this cooperation and showing others what we can contribute. In another project, a planning process for geographic information systems (GIS) development on a park-by-park basis was initiated to plan for a three-fold increase in funding for GISs.

In these and other ways, we have increased our capability to manage natural resources. But with these efforts, we are only beginning the process of meeting these extensive resource management needs.



PROTECTING AND RESTORING OUR RESOURCES

Front Page News



Survival of the Spotted Owl Sparks Controversy

By Bruce B. Moorhead, Wildlife Biologist,
Olympic National Park

Surrounded by controversy, the northern spotted owl "made" the threatened and endangered species list in 1990. The deep-forest owl's survival depends on the presence of old-growth forest habitat. This habitat is being destroyed by logging and natural disturbances, and much controversial attention is focused on the use of nonpark public lands for logging.

The national parks in the spotted owl's range play an important role in the preservation of the species. According to an estimate made by the Interagency Scientific Committee formed to create a conservation strategy for the bird, 8% of the suitable habitat remaining in Washington, Oregon, and California is in national park areas. Despite a lack of systematic surveys, about 110 breeding pairs of spotted owls were estimated to occur in eight park areas, including some 60 to 80 pairs in Olympic National Park.

In 1990, the Interagency Scientific Committee released the "Thomas Report," outlining the conservation strategy. Integral to the strategy is the creation of a series of large, interconnected habitat conservation areas throughout the owl's range. On the Olympic Peninsula, a habitat conservation area of about 676,000 acres is proposed, at least half of which is in Olympic National Park. The committee report expressed concern about the isolation of spotted owls on the Olympic Peninsula, due to the 60-mile-wide patchwork of cutover forest lands that now separate the Peninsula population from populations elsewhere in Washington State.

To accurately assess this and other concerns, the Interagency Scientific Committee recommended that an owl inventory be completed in each habitat conservation area within three years. Efforts to inventory spotted owls in Olympic National Park have been in place since 1985. Surveys have been carried out each year to assess owl presence, distribution, and habitat use in various parts of the park. Unfortunately, progress has been difficult and slow. The park's densely forested, mountainous interior can be reached by only a few roads and about 600 miles of trail.

Surveys to date have mainly been accomplished by broadcasting spotted owl calls at night on backcountry trails along transects to sample owl responses. Daytime follow-up visits are used to confirm the identity of the birds found. Most locations are sampled from three to six times during a field season in order to confirm the presence of an owl breeding pair. In 1990, 23 birds were also leg-banded to aid in monitoring the population, in cooperation with U.S. Forest Service researchers.

About 20-30% of the park has been surveyed, and 25 owl pairs confirmed to date. Results suggest that spotted owls occur widely throughout the park in low densities and primarily at lower elevations. Spotted owls are near the northern limit of their distribution on the Olympic Peninsula and are further limited by high mountains across the park interior. Elevation this far north seems to be a limiting factor, indicated by the fact that nesting pairs have not been found above 2,000 or 2,900 feet elevation, respectively, on the west and east sides of the park.

The relatively small numbers and the restricted distributional pattern suggest that the park owl population may be in jeopardy if further isolation from birds around the park occurs due to habitat fragmentation. Another threat may also come from the barred owl. This invading competitor species has been documented in the park for the first time and may be displacing spotted owls at some locations.

With adequate funding, an initial inventory of spotted owl distribution and abundance can be completed in about three to five years within major park drainages and proposed habitat conservation areas. Population trend monitoring may also be conducted at selected locations, and an overall assessment made of the amount of suitable and occupied habitat with geographic information systems technology.

Proposed Action Will Improve Visibility In the Grand Canyon

By Mark Scruggs, Chief Research Branch, Air Quality Division

In 1987, the electric utility industry conducted the Winter Haze Intensive Tracer Experiment (WHITEX) to assess the impact of the coal-fired Navajo Generating Station power plant on visibility in Grand Canyon National Park. The Environmental Protection Agency has reviewed the results of WHITEX and the National Academy of Sciences assessment of that experiment. On February 1, 1991, the Environmental Protection Agency announced its proposal to require reductions in Navajo Generating Station pollutant emissions.

This proposal represents the first regulatory action by the Environmental Protection Agency instigated solely to improve visibility. The agency based its action on evidence provided by the Park Service report that the Navajo Generating Station is a significant contributor to visibility impairment in the Grand Canyon National Park. (The report was based on WHITEX data and was supported by the National Academy of Science.) The Environmental Protection Agency further stated, "The Grand Canyon, a natural resource of immense value and a worldwide symbol of our country's spirit and beauty, routinely is shrouded by a wintertime haze that limits visibility and damages enjoyment of the vistas. Action must be taken now to protect one of the earth's most priceless natural wonders."

The Environmental Protection Agency considered several different sulfur dioxide emission reduction scenarios (from 50% to 90% removal of sulfur dioxide), but recommended a new sulfur dioxide emission limit for the power plant that reflects a 70% reduction in currently allowed emissions. Citing that the National Academy of Science review committee felt there was too much uncertainty in the WHITEX estimates of the fraction of sulfate particles (derived from sulfur dioxide emission) and resultant haze in Grand Canyon National Park that was attributable to the Navajo Generating Station, the agency did not propose higher levels of control. They have, however, solicited public comment on their proposal, including the level of control. A public hearing was held in March 1991. The Environmental Protection Agency will make a final decision after review of the comments.

Bison and Brucellosis In Yellowstone

By M. Mary Meagher, Research Biologist,
Yellowstone National Park and John G. Dennis,
Supervisory Biologist, Wildlife and Vegetation Division

Bison in Yellowstone National Park are managed according to a policy of natural regulation that was adopted in the 1960s. Under this policy, the bison herds grow or decline in response to the natural balance between births and deaths. In harsh winters, many die, providing food for the park's meat eaters. If the weather is mild, more bison survive, some reaching the ripe old age of 15 or 20 years. In the last few decades, the bison population has grown steadily, especially during the relatively mild winters of the 1980s.

In the mid and late 1980s, some of the bison in this larger population migrated outside of park boundaries into areas that were once traditional winter range, but that now contain a variety of human developments. This migration caused consternation for the human residents. They feared not only the property destruction or human injury that the large beasts could cause, but also the potential that bison carry the economically destructive cattle disease, brucellosis. Although bison within Yellowstone are under federal legal protection, once they leave the park they fall under state jurisdiction and are managed according to state law. Because of concern about brucellosis, State of Montana game wardens or state-licensed sport hunters in recent years shot some of the seasonally migrating bison when they moved outside of the park. These efforts led to a total of 187 animals killed in the winters of 1984-85 through 1987-88, and 569 more in the single winter of 1988-89. While the killing of these bison was largely viewed as a benefit within Montana, many people throughout the rest of the country became vociferously upset.

Expecting future recurrences of large winter migrations, the National Park Service, the Montana Department of Fish, Wildlife and Parks, and the U.S. Forest Service have agreed to develop a long-range management plan for Yellowstone bison that migrate into Montana. This planning process receives technical support from an interagency Ad Hoc Technical Committee on Brucellosis in Wildlife of the Greater Yellowstone Area formed in 1988. Participants in this technical committee include the Animal and Plant Health Inspection Service; the Idaho, Montana, and Wyoming State Veterinarians; the U.S. Fish and Wildlife Service; the U.S. Forest Service; the National Park Service; Texas A&M University; and the Idaho, Montana, and Wyoming Game Departments.

In addition to preparing a long-range management plan, the cooperating agencies are seeking to improve public understanding of the biological and economic factors involved in managing the bison and to obtain public views on management options through wide dissemination of informational materials and activities. To date these materials have included a pamphlet on "The Yellowstone Bison: Managing a National Heritage," a review paper entitled "Yellowstone Bison: Background and Issues," a notice of intent to prepare an environmental impact statement for the bison management plan, and public scoping meetings in three locations in Montana.

Because they knew that the long-term planning process would take at least two years to complete, the Montana

Department of Fish, Wildlife and Parks and the National Park Service in 1990 developed an interim bison management plan. This cooperative plan established four actions to prevent unwanted impacts to private property: 1) park staff would haze bison in an attempt to keep the animals within Yellowstone National Park; 2) the state, with the assistance of park personnel as requested, would destroy cow bison leaving the park, giving the resulting meat to the needy; 3) the state would capture, neuter, and sell live bison calves leaving the park, with proceeds from the sale used to finance the processing of meat from the cows; 4) the state would selectively control bull bison outside the park posing threats to property or human safety.

The goal of the interim plan was to focus management effort on strategies that minimize the risk of transmission of brucellosis to domestic cattle, the number of bison that must be shot, and the impact of bison on private property and human safety. The environmental assessment accompanying this plan concluded that there would be little likelihood that removal of migrating animals during this interim period would cause any long-term bison population viability problems.

Over the long-term, the most achievable strategy for managing bison and brucellosis in the Greater Yellowstone Area will be one that prevents the transmission of disease from wild bison or elk to domestic animals. Such a strategy could include preventing the intermingling of domestic and wild animals in selected locations during times when infectious materials produced by wild animals are likely to be in the environment; destroying high risk animals on federal land before they can emigrate onto private and other lands; grazing only unsusceptible livestock (steers and spayed heifers) in areas simultaneously used by wild animals; delaying the turnout of domestic livestock onto federal lands until after the infectious time period has ended each spring; and developing and using better vaccines and/or vaccination methods for both domestic and wild animals.

While these techniques are not likely to eliminate the disease from the area, they may provide the opportunity for all components of the Greater Yellowstone Area landscape to coexist in a cooperative and mutually beneficial management system.

DOI Objects to Proposed Power Plants

By Molly Ross, Assistant Division Chief , Air Quality Division

For the first time since the Clean Air Act Amendments of 1977 provided the regulatory mechanism, the Department of the Interior has asked a state permitting authority to deny permits to major new sources of air pollution to avoid adverse impacts on park resources. Adopting the National Park Service's recommendation, the Assistant Secretary for Fish and Wildlife and Parks has found that the pollution from these power plants, individually and collectively, would contribute to adverse impacts on Shenandoah's resources. Therefore, the Assistant Secretary has asked that the Commonwealth of Virginia deny the permits for these power plants unless the proposed pollution increases are offset by pollution reductions from existing sources.

Approximately twenty new coal-fired power plants are planned within a 200 kilometer radius of Shenandoah National Park. These power plants could produce over 35,000 tons per year of sulfur dioxide and 70,000 tons per year of nitrogen oxides. Virginia Power Company intends to use these power plants to generate up to 7,000 additional megawatts of electricity over the next decade.

The Department's action relies on extensive research and monitoring of air quality impacts conducted by the park, the Air Quality Division, the University of Virginia, and others. The results of this work are summarized in "Technical Support Documents" which discuss the impacts of sulfur oxides, nitrogen oxides, and ozone. These discussions include visibility degradation, acidification of streams, possible damage to aquatic biota, injury to vegetative species, and air pollution concentrations harmful to human health. Based on the research and monitoring results, the Commonwealth of Virginia and the Environmental Protection Agency have agreed with the Department that current air pollution levels cause adverse impacts on Shenandoah's resources.

Whether the Assistant Secretary ultimately influences the decisions on the proposed air quality permits, however, may depend on the government agencies' ability to model quantitatively the individual and collective contributions of the new sources to the air pollution levels at Shenandoah. In collaboration with the Environmental Protection Agency, the Air Quality Division is working with state-of-the-art models to determine these impacts.

Dam Affects Downstream Resources

By Jerry Mitchell, Resource Management Specialist, Grand Canyon National Park

When Glen Canyon Dam was built in the 60s, a great number of changes occurred on the Colorado River. The effect of these changes on the downstream resources within Grand Canyon National Park and Glen Canyon and Lake Mead National Recreation Areas is now the focus of intensive research.

Before the construction of the dam, the hydrology of the sediment-laden Colorado River was characterized by low flows in fall and winter and floods in spring and summer. Now the clear water flow is distributed throughout the month and released on a daily basis, with peak releases coinciding with peak electrical power demand. The result is a fluctuating discharge from the dam which for years has been suspected of having an effect on downstream resources, including sediment deposits, riparian vegetation, native fish, archeological sites, and recreation.

Because of growing concern over these impacts, the Secretary of Interior authorized the Glen Canyon Environmental Studies in December of 1982. The Bureau of Reclamation, the National Park Service, the U.S. Fish and Wildlife Service, the U.S. Geological Survey, the Arizona Game and Fish Department, and numerous contractors participated in Phase I of these studies. The Phase I studies concluded that the current operational regime for the dam (i.e., magnitude and timing of releases) significantly altered downstream resources.

The National Academy of Sciences was asked to review the products of the Phase I Studies. The review committee agreed that changes in the operation of Glen Canyon Dam were reflected in the measurable changes in the natural resources in the downstream riparian corridor. They also concluded that the studies were inadequate due to their failure to consider management options and assign values to downstream resources so that management goals could be set.

As the Glen Canyon Environmental Studies moved into Phase II, the National Park Service insisted on implementation of the National Academy of Science's suggestion that alternative dam operations should be studied. The National Park Service also developed resource priorities and management objectives, to be used to assure that the studies will serve as a foundation for decision-making.

Study of sediments was identified as the first priority in National Park Service management, since it is the pivotal link in the system for all other components. The endangered native fish, identified as priority two, require sediment for the low velocity, warm water backwaters that serve as nursery habitat; riparian vegetation requires sediment for substrate; archeological sites require sediment for stability; and recreationists need sediment for camping sites.

Phase II studies are ongoing and are focused on the range of steady and fluctuating flow alternatives. The studies also allow a comparative analysis of several ranges of fluctuations and rates of discharge change. Special research flows (discharge periods) have allowed researchers to comparatively evaluate the relative influence of all of these operational regimes. The over 50 Phase II research projects include those that evaluate the influence of alternative dam operations on sediment deposits, riparian vegetation, native fish and their habitat, sport fish, trophic levels (including aquatic invertebrates), camping beaches, on-river contacts and crowding, and power production.

Preliminary results indicate that 1) steady flows have less influence on sediment deposits than fluctuating flows, because of several mechanisms (i.e., tractive erosion during periods of increased velocity and increasing flows, runoff, and seepage of beach-stored ground water as water level drops); 2) steady flows contribute more to higher water temperatures in backwater habitats than fluctuating flows, due to the flushing action of fluctuating flows; 3) steady flows have less leaching influence on soil constituents than fluctuating flows; and 4) fluctuating flows contribute to dessication of aquatic invertebrates, stranding of trout, and inundation of wading trout fishermen. Archeological sites along the river are being inventoried, and the potential assessed for dam operation impacts.

There are a number of areas that require long-term research and monitoring (e.g., water flow routing, cues that are important in native fish reproduction, spawning habitat, etc). Long-term monitoring programs have been initiated in order to better understand flow routing and its influence on sedimentation and sediment storage in channels and eddies. It is hoped that sediment brought in by tributaries and stored as bed-load in the channel will someday provide the supply needed to manage and maintain the sediment deposits that are so pivotal to the preservation and maintenance of all ecosystem components, processes, and relationships.

In order to minimize the damage to the downstream resources, the Park Service is negotiating with the Bureau of Reclamation and other cooperating agencies to establish an interim discharge regime until an environmental impact statement is completed.

Everglades Fights for Its Life

By Michael Soukup, Director, South Florida Research Center, Everglades National Park

The health of the Everglades ecosystem depends on maintaining appropriate quantity, timing, distribution, and quality of the water. Unfortunately, little effective control of the these factors has been achieved since the establishment of Everglades National Park. Indeed, many think that the park has been fundamentally altered by the massive water management activities higher in the watershed, and that it may be dying.

To reverse the decline, Everglades National Park has instigated major initiatives to restore water quantity, timing, and distribution. The major water quality issue is being approached through litigation. In 1988, the Department of the Interior worked with the Department of Justice to bring suit against the South Florida Water Management District and the Florida Department of Environmental Regulation. The suit alleges that the state agencies failed to protect these federal lands from agricultural runoff impacts.

The Everglades system was historically a very nutrient-poor environment. Phosphorus, often a limiting nutrient in freshwater, has normally been especially scarce in the Everglades, with background levels approximating those in natural rainfall (around 4 to 7 parts per billion total phosphorus, as wet deposition). The dominant sawgrass/wet prairie communities are finely tuned to thrive at these low nutrient levels. These characteristic Everglades communities are stable unless that nutrient supply is altered: then other plant species and community types are favored.

Since the 1970s, the effects of increased nutrients on the Everglades have been documented in the scientific literature. The primary source of these nutrients is the Everglades Agricultural Area, an area of 700,000 acres south of Lake Okeechobee underlain by very rich muck soils. Drainage and intensive water level management to support farming of sugar cane, vegetables, and sod result in soil oxidation at an average rate of 1 inch per year and mobilization of over 200 tonnes of phosphorus per year, with some contributions of phosphorus from fertilizer.

Some of this tonnage used to be pumped into Lake Okeechobee. But efforts in the 1970s to save this lake resulted in all the nutrients being sent south, directly to Loxahatchee National Wildlife Refuge and eventually to Everglades National Park. The impact on Loxahatchee is enormous. Impacts to the Everglades have been somewhat buffered by the state-owned wetlands between the agricultural area and the park, which have removed as much as 97% of the phosphorus. Unfortunately, this results in massive alterations in the native Everglades plant communities of these wetland areas. And impacts to the park are increasing, in spite of the protection afforded by the wetlands. Elevated phosphorus levels in sediments are detectable 3 to 4 miles into the park. A range of documented vegetative responses occurs along the park's northern boundaries.

The objective of the lawsuit is enforcement of state water quality laws. Farming can coexist with natural areas if nutrient and water budgets are carefully managed. Application of the State Class III water quality standard, which prohibits nutrient enrichment at levels that cause imbalances in flora and fauna, is one means of achieving that compatibility. Similarly, the park's Outstanding Florida Water designation provides a guarantee of nutrient levels consistent with that delivered in 1978 (the year previous to designation) with an allowance for natural and cyclic variation. The technical challenge for the Service has been to document the park's historic water quality levels and to define them as numerical water quality standards that will guarantee achievement of those levels. The degree to which we are successful will determine an important facet of the future of the Everglades.

PROTECTING AND RESTORING OUR RESOURCES

Unsung Stories

Achievement Awards Recognize Excellence

In July 1989, the Director created two new annual awards for National Park Service employees. The Director's Award for Natural Resources Management recognizes creative resource management projects and programs. The Director's Award for Science recognizes outstanding contributions to scientific research or research programs in the parks. The recipients of the award receive $2,500 and a plaque honoring their achievement.

When announcing the 1990 winners, the Director said, "I hope that recognition of these achievements will demonstrate the importance that must be placed on natural resource management to meet the challenges of the future. No less important, these awards should also underscore how important it is that we have solid scientific information for making resource decisions."

Director's Award for Natural Resources Management: David Haskell

David Haskell, the Chief of Natural Resources and Science at Shenandoah National Park, received the Director's 1990 Natural Resources Management Award. Haskell was honored for his leadership in a six year effort to implement a long-term ecological monitoring program at Shenandoah National Park. Haskell oversaw the development of the program, which, as one of the first comprehensive long-term inventory and monitoring programs, was developed virtually from scratch. One of the end products of the monitoring program was a set of field manuals, coauthored and coordinated by Haskell, that he hopes will be useful to other parks interested in implementing a monitoring program.

As the ecological monitoring project progressed, Haskell recognized that geographic information system (GIS) technology would be essential to support the inventory and monitoring program. Shenandoah now has one of the most extensive operational GISs in the Park Service.

Haskell has not spent all of his time at Shenandoah on the monitoring program. He also oversees an air quality program that has been called "the eastern flagship." This program incorporates air monitoring and air quality effects research into an extensive and proactive management program that has been effective in reducing local pollution emissions. He coauthored the inventory and monitoring section of NPS-77, the Natural Resources Management Guideline, and was part of the task force that developed the Research Administration section of the guideline.

When Haskell came to the Shenandoah National Park in 1974, no full-time resource managers were on staff. When he became a resource management specialist in 1981, he began to work closely with John Karish, the Mid-Atlantic Regional Chief Scientist, to build a resource management program at Shenandoah that integrated research data immediately into resource management programs. The park now has a separate Division of Research and Science, eight professional resource managers on staff, and conducts a comprehensive monitoring and management program and a research program that averages 40-50 research projects a year.

According to Haskell, however, a manager is only as good as his staff. "I would never have gotten this award on my own," says Haskell. "I've got a gungho staff that always makes me look good."

Director's Award for Science: Francis J. Singer

Francis (Frank) J. Singer, a research ecologist formerly with Yellowstone National Park's Division of Research, was presented with the Director's annual Award for Science for 1990. Many of Singer's contributions have helped resolve some of Yellowstone's most difficult and contentious natural resource issues. In a memo, the Director noted Singer's extraordinary personal research productivity related to elk and other ungulates and their habitat in the park's northern range. In addition to his own research activity, Singer supervised or provided liaison to about 40 other scientists working on subjects related to northern range questions.

In the production of the 575-page report to Congress "Wolves for Yellowstone?" Singer played a pivotal role as author, reviewer, and coordinator. His compilation and analysis of the 43 ungulate herds in the greater Yellowstone ecosystem represented the first time a synthesis of that sort had ever been prepared, and was of enormous value to other scientists in their predator-prey modeling efforts. In the aftermath of the great Yellowstone fires of 1988 and the severe winter of 1988-89, Singer assessed and evaluated the mortality of large animals and presented the results of this research in the prestigious journal *BioScience*, as well as in three popular articles and in presentations to numerous scientific and government groups. In his "spare time," Singer managed to coauthor the section on Native Animal Management for NPS-77, the Natural Resources Management Guideline; organize a workshop on ungulate carrying capacity and population models attended by about 100 scientists; and coordinate, edit, and write parts of a National Park Service monograph on wolves, due to be published in 1991.

In the spring of 1991, Singer and his family left Yellowstone for Ft. Collins, Colorado, and a new assignment relating to bighorn sheep problems in Rocky Mountain Region parks. After Singer's departure, Yellowstone's Superintendent Bob Barbee lauded his productive six-year tenure in the park and observed, "I think we will need two--no--three regular scientists to replace Singer around this place...he will be missed!"

In addition to the winners, the following individuals were nominated for the awards in 1990.

Science: Gary Davis, Research Scientist, Channel Islands National Park; David Foster, Biologist, Ozark National Scenic Riverways; Robert Johnson, Hydrology Program Manager, South Florida Research Center; William Malm, Research Physicist, Air Quality Division; and R. Gerald Wright, Research Biologist, University of Idaho Cooperative Park Studies Unit (CPSU).

Natural Resource Management: Kathleen M. Davis, Resource Management Specialist, Southern Arizona Group; Richard Dawson, Southeast Regional Office; Riley Hoggard, Natural Resource Management Specialist, Prince William Forest Park; Nora Mitchell, formerly Natural Resource Manager, North Atlantic Region; Julie Van Stappen, Resource Management Specialist, Apostle Islands National Seashore; and Charles Wood, Supervisory Ecologist, Glen Canyon National Recreation Area.

Director James Ridenour and Gene Hester, Associate Director, Natural Resources, present the award to Frank and Carol Singer.

The Return of the Native: Revegetation in the Rocky Mountain Region

Revegetating disturbed areas is an ongoing park management concern. Road work and construction projects leave behind them a wake of destroyed vegetation, requiring extensive rehabilitation. In the past, nonnative plant materials were often used because they were inexpensive, available, and sure to grow. As the commitment to returning park ecosystems to a natural state has grown, however, this alternative has become less and less attractive.

Unfortunately, reestablishing native vegetation in these areas is not a simple task. Natural reestablishment may be too slow, allowing infiltration of exotics. And it is often difficult to find a commercial source of native plant materials in the quantity needed. Resource managers around the Park Service have come up with some innovative ideas to meet this challenge. The following articles describe a few of these efforts.

Native Plants Take Root in the Rocky Mountain Region

By Sarah Wynn, Vegetation Restoration Coordinator, Rocky Mountain Region

A push is on in the Rocky Mountain Region to rehabilitate disturbed sites with native vegetation. Parks in the region are writing revegetation plans, working with the Soil Conservation Service to obtain plant materials, and monitoring the results to improve future revegetation success.

Extensive programs designed to rehabilitate Federal Lands Highways Program (FLHP) road corridor disturbance are beginning or continuing at Grand Teton, Bryce Canyon, Mesa Verde, Yellowstone, and Glacier. Each of these parks has selected native species believed to be environmentally appropriate and genetically acceptable for their particular rehabilitation needs. Using FLHP funding, native seeds or cuttings are collected from the parks to be propagated at a Soil Conservation Service plant materials center. Here, native grass seed or shrubs are propagated over several seasons to produce large quantities of seed, which are then returned to the park for planting.

Canyonlands and Glen Canyon are developing programs for propagating their own native species to revegetate nonroad construction projects. Using these materials, Glen Canyon National Recreation Area has recently completed the restoration of two abandoned oil and gas test sites. Monitoring efforts to track the restoration effort will begin this spring.

In order to coordinate their revegetation program, Rocky Mountain National Park is in the process of writing a revegetation/restoration plan for the entire park. The plan will include an inventory of all disturbed sites in the park and park objectives and priorities. In addition, the plan will identify the source of plant materials (i.e., the park, the Soil Conservation Service, or commercial growers). By identifying parkwide revegetation needs through the planning process, revegetation efforts will be prioritized. The development of native plant propagation programs can thus begin several years before the actual revegetation effort, and the park will be sure to have sufficient native plant materials on hand at the time they are needed.

In order to add to our information on how to successfully revegetate using native species, all ongoing efforts should be monitored, and, if possible, a research plan developed. Biologists at Canyonlands have developed a research plan to test methods that may enhance grass seeding success. As Canyonlands has been experiencing severe drought, receiving only 4 inches of their normal 8 inches of annual precipitation, any method that will enhance seeding establishment is important to a successful revegetation effort. Canyonlands will be testing the success of spring seeding versus fall seeding and three water treatments. In addition, Canyonlands will test inoculating areas with ground-up microphytic crust to determine if their presence enhances grass germination and establishment.

Joshua Tree National Monument Nurtures Desert Natives

By Mark S. Holden, Vegetation Technician,
Joshua Tree National Monument

For five years, Joshua Tree National Monument has been reconstructing and realigning roads under the Federal Lands Highway Program (FLHP). All along the road construction corridors, roadsides are stripped of vegetation. Left to itself, reestablishment of native vegetation in these areas would take decades, if it ever occurred at all. And few nurseries propagate native desert plants that could be used in reestablishment efforts due to their lack of commercial importance. These two factors led Joshua Tree to take a stab at growing their own plants for roadside revegetation.

Five years ago, the park boasted only a small kit greenhouse and fenced area. It now has 575 square feet of greenhouse area, and over 12,000 square feet of growing space. To date, the nursery has grown and out-planted over 5,000 plants along 15 miles of reconstructed road. The nursery presently is able to propagate over 60 species of Sonoran and Mojave desert plants and continues to have success on the more difficult species.

Joshua Tree staff plant delicate desert seedlings in "pots" fashioned from PVC sewer pipe.

Because of their unique ecology and growing requirements, desert plants are not easy to produce. Joshua Tree has become a forerunner in the development of new materials and techniques in propagation of desert plants. Two greenhouses allow the staff to start plants from seed and cuttings, which sometimes require long and intense cultural procedures. Instead of standard squat nursery pots, tubes of rolled newspaper filled with potting mix are used to develop seedlings. Economical and easy to prepare, these tubes promote the growth of the plant's central tap root, which is important in the development of desert plants.

These tubes are transplanted into a 30 inches tall, 6 inches diameter "pot" fashioned from PVC sewer pipe. The pots are cumbersome, and a power auger is needed to plant them in the field. However, the plants go into the ground with a well-developed root system, and field survival presently runs between 75 and 90%.

Even the potting mix was developed in-house. The use of straight desert soils proved disastrous. The high amounts of caliche clay hardened like adobe with the frequent wetting required in the nursery environment. Instead, a highly porous, fast-draining mix was developed using equal amounts of washed sand and perlite. When certain important species failed to thrive in this soil, a time release fertilizer and a small amount of organic matter were added.

Continuous new uses for desert vegetation are being discovered in the Monument. The use of smaller pots is being examined, as they are better suited for use in more remote areas, such as Joshua Tree's 200 miles of wilderness roads. An interpretive demonstration garden is being developed using plants which consume less water, an important concern in California's fifth year of drought. Numerous residences, entrance stations, visitors' centers, and other buildings need native desert vegetation for landscape.

With the seemingly difficult problem of desert plant propagation solved, the only problem left is to grow enough to meet all of Joshua Tree's needs!

Insular Populations Create Management Challenges

By Thomas C. Wylie, Natural Resources Specialist,
Rocky Mountain Region

National park areas often act as "biological islands," particularly for populations of large mammals. In the Rocky Mountain Region parks, bison provide excellent examples of the problems associated with the management of insular populations. In Yellowstone National Park, the bison roam freely within the park, but in recent years have been controlled once they are outside of park boundaries. This management policy is being reevaluated and the new strategy incorporated into a long-term management plan. This topic is discussed on page six of this report in the article on "Bison and Brucellosis In Yellowstone."

At Wind Cave, Grand Teton, Theodore Roosevelt, and Badlands national parks, the bison herds are the result of restorations into limited habitats. This has created distinctive management problems and practices, which generally involve fencing the herd and periodically controlling population numbers by removing animals in some fashion. The Jackson bison herd at Grand Teton National Park moves freely in and out of the park on a seasonal basis. However, regular population control practices are required. As herd size has increased, bison problems outside of the park have increased, including conflicts with the management of the nearby National Elk Refuge. A 1988 four-agency interim agreement effective through 1994 has been adopted for the management of the Jackson herd. During this period, the herd will be maintained at ninety to one hundred animals, and a long range bison management plan will be developed. Herd reductions have been accomplished by donating animals to Indian tribes and by public hunting.

At Wind Cave, Theodore Roosevelt, and Badlands national parks, bison and other restored ungulates are contained within small geographic areas. Manipulative management is required. Fences are necessary to prevent trespass of bison onto neighboring lands. Herd numbers are periodically reduced in order to prevent overgrazing. Although these herds are certified brucellosis-free, testing and vaccination programs are in place to prevent recurrence of the disease.

In accordance with management policy, Indian tribes are given preference for the disposal of surplus wildlife generated by herd reductions. These animals are mostly disposed of as live animals to the tribes, some of whom are establishing their own bison herds. Generally, the surplus animals are transferred to tribes in accordance with written agreements, but key provisions vary from park to park and result in confusion. Not all animals are disposed of under coverage of agreements, and there have been instances where false tribal status has been used to fraudulently obtain bison. Tribes have also accepted live bison without the wherewithal to properly care for them.

Because of recurring problems associated with bison management disposal of surplus wildlife, the Rocky Mountain regional office has created a task force to 1) review policy, regulations, and legislation affecting the disposal of wildlife; 2) review appropriate Rocky Mountain Region park programs for the disposal of surplus wildlife (particularly bison and elk); 3) analyze the problems associated with disposal; 4) develop research needs related to the management of these insular populations; 5) prepare alternatives and options for disposing of surplus animals; and 6) recommend actions and policy, as warranted.

The task force has not yet completed its work, but a few of the preliminary research needs identified can be summarized. How should culling for herd reduction be conducted? Resource managers need to know what animals to remove in order to maintain a "natural" age and sex structure, and, if appropriate, genetic variability. Additionally, since many of the ungulate populations in national parks are the result of restorations, there is a need to establish and maintain a data base for tracking the genetics of the various herds. Another concern is that there still appears to be a lack of information on what the optimum condition should be of ranges utilized by free roaming bison and elk. The criteria on which each park bases its need to manipulate ungulate populations should be reviewed and refined. Criteria developed for livestock production are not acceptable. Finally, the ecological implications of ungulate removals need to be addressed. Are there ecological changes resulting from the removal of carcasses from the ecosystem? Should natural population cycles be simulated in population control programs?

It is not expected that the task force report will provide all the answers to managing ungulate populations in limited habitats. Where answers are not forthcoming, it is hoped that good questions will be asked to direct further inquiry.

Cooperating to Create a Compromise

By Ken Czarnowski, Hydrologist, Water Resources Division

Seven miles from its headwaters, Reese Creek meets the Yellowstone River just inside the northern boundary of Yellowstone National Park. In the early 1980s the Royal Teton Ranch, also known as the Church Universal and Triumphant, purchased land adjacent to the park's northern boundary. Shortly thereafter, they moved their headquarters and several hundred members to the area and began intensive cultivation of the river bottomlands. During most of the irrigation season the Royal Teton Ranch diverted much of the water from Reese Creek by means of two ditches, using an alleged senior water right. Another adjacent landowner diverted the remaining water for irrigation.

The National Park Service believed these diversions were excessive, that they injured the service's alleged senior water rights, and that they affected the park's ability to fulfill its mandate to maintain the scenery, preserve the wildlife, protect the natural ecosystem, and preserve a viable cutthroat trout fishery.

The National Park Service and the other water users were drawn to the negotiating table by the Montana Statewide Water Rights Adjudication. If a settlement could not be reached among the parties, the waters of Reese Creek would be apportioned by the Montana Water Court in the midst of a cloud of uncertainty surrounding seniority of water rights. After nearly five years of discussions, a stipulated settlement was reached on July 6, 1990, just days before the parties were to appear in court. This agreement was crafted by the Solicitor's Office, the Water Resources Division, and legal counsel for the Royal Teton Ranch.

Although concessions were made by all parties, it was not until a "sharing of risk" was assumed by the water users that a settlement became possible. The parties combined a number of water rights with early priority dates and agreed to share the first 3 cubic feet per second on a pro-rata basis. In this way, during dry years, some water would always be available for instream flow while irrigators would receive a portion of the flow for crops.

The Reese Creek settlement was described by counsel for the Royal Teton Ranch as one of the most complex and unique to be submitted to the court. The process of negotiation, albeit protracted and laden with risk, allowed the parties to explore options that might not have been possible through litigation.

Everyone's at Home on Great Basin's Range

By Mac Brock, Resource Management Specialist, Great Basin National Park

The 1986 legislation which created Great Basin National Park provided for continued livestock grazing at the levels coincident to pre-park establishment. Five of the park's seven grazing allotments are shared with the U.S. Forest Service, and one is shared with both the U.S. Forest Service and the Bureau of Land Management. This interdependence of park livestock grazing with outside agencies and private enterprise encouraged cooperation with other institutions in the development of a coordinated resource management approach. The park has entered into a cooperative agreement with Oregon State University to develop an interim plan focusing on livestock grazing management, and a comprehensive range management plan for the continued preservation of range resources. The range management plan will be the product of an evaluation of not only livestock grazing influences, but also related causal factors. These factors include the historic role of fire and the effect of present fire control, changes in vegetation resulting from the widespread overgrazing at the turn of the century in the Great Basin, changes in vegetation as a result of changing climate, and the influence of wildlife populations on vegetation dynamics.

Great Basin National Park has developed cooperative agreements with the U.S. Forest Service, the Bureau of Land Management, and the Nevada Department of Wildlife to maximize the involvement of these agencies in the development of a holistic range resource management program. Initial involvement has centered on communication with the agencies and solicitation of suggestions on each agency's views of the Great Basin Interim Grazing Management Plan. Future coordination is planned to involve these agencies, private ranching interests, and environmental groups in the development of the range management plan. This should lead to a management strategy which will minimize visitor/livestock conflicts and environmental impacts and ensure preservation of park resources.

Wildlife Mitigation Serves as Resource Management Tool

By Karen Taylor-Goodrich, Natural Resources Specialist, Coulee Dam National Recreation Area

When Lake Roosevelt flooded 70,000 acres behind the Grand Coulee Dam in 1939, large numbers of wildlife losses occurred along the Upper Columbia River Basin. Since that time, little effort has been made to address these wildlife losses due to the lack of a formal mandate to mitigate such project-related losses.

More recent legislation recognized this disparity between hydroelectric development in the Columbia River Basin and mitigation for wildlife losses. The Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Power Act) directed Bonneville Power Administration to fund fish and wildlife mitigation when damage occurs as a result of federally funded hydroelectric development projects.

In response to the Power Act's mandate, Phase I of the Columbia Basin Fish and Wildlife Program wildlife mitigation process was implemented. The Grand Coulee Dam mitigation effort involved National Park Service participation in interagency negotiations that resulted in the construction of kokanee salmon hatchery and rearing facilities on Lake Roosevelt. This project served as mitigation for anadromous fish losses due to dam construction.

In Phase II of the program, the focus will be on wildlife losses. In order to use the mitigation process to help meet park resource management objectives, the National Park Service is working cooperatively with other federal, state, and tribal agencies to develop projects that incorporate endangered species recovery plan goals to mitigate for wildlife losses.

One project proposal submitted by the National Park Service for Bonneville Power Administration funding involves developing a hack site to reestablish peregrine falcons in their historic range in the Lake Roosevelt area. Along with restoring a species that vanished from the area decades ago due to pesticide use and habitat loss, this project also mitigates in "like kind" for a peregrine nest site that was lost during the construction of the Grand Coulee Dam. The project also coincides directly with the goals of federal and state peregrine falcon recovery plans for the region.

The National Park Service is also developing proposals for projects to address wildlife habitat loss. Projects that enhance bald eagle nesting and winter habitat and others that involve the development of experimental wildlife habitat enhancement and management areas will help meet park objectives for resource management.

National Park Service leadership in these mitigation projects will ensure long-term monitoring and protection of the resources. As an active participant in an important interagency effort, the National Park Service decision to become involved in wildlife mitigation efforts for the Coulee Dam Project represents an integrated approach to managing natural resources for the future.

Wildlife mitigation should return peregrines to their historic range in the Lake Roosevelt area.

TRACKING OUR NATURAL RESOURCES

Inventory and Monitoring Progresses at Glacier National Park

By Kathy Dimont and Kim Keating,
Research Assistants, Glacier National Park

Over the past several years, Glacier National Park's inventory and monitoring program has progressed rapidly. Concurrent development of information, inventory, monitoring, and data systems has taken place.

Monitoring parameters have been designed to note various symptoms of ecosystem stress, including: 1) declining native species diversity, 2) changing trophic diversity, 3) changing species size distribution, 4) changing incidence of disease, 5) changing amplitude of population fluctuations, 6) regressive succession, 7) changing standing crop biomass, 8) changing gross or net primary productivity, 9) changing relative energy flow to grazers and/or decomposers, 10) changing mineral macronutrient stock, and 11) changes in the mechanisms and capacity for damping undesirable oscillations.

Data on the physical and chemical environment provide a necessary base for constructing cause and effect hypotheses and for distinguishing among natural and anthropogenic disturbances. Air and water monitoring program data will be collated, and analytical and reporting protocols developed to ensure that results are conveyed to managers in a timely manner. The following objectives are sought: develop park-based air and water data bases to ensure availability of information, develop analytical protocols and analyze existing data for trends, and develop reporting protocols to assure communication of results to park managers.

Inventories of plant species and communities contribute directly to understanding the structure and function of ecosystems. They improve the design of field studies and are necessary to interpret and extrapolate other information, including remote sensing data. Glacier's park species list is believed to be relatively complete. Future work will include assuring the completeness of that list, integrating vegetation information into other studies and programs, and analyzing vegetation data recently compiled.

Stand-age maps based on fire histories provide basic information for interpreting and extrapolating studies of community composition and distribution and are available for the west side of the park.

The park monitoring strategy calls for biological monitoring at three ecological levels: landscape, community, and population. Research on community level measures of biotic integrity has been initiated for terrestrial communities. Landscape and population monitoring will be addressed next.

Regional land use patterns are a central element of ecosystem management, and changes in those patterns comprise one of the greatest potential threats to park resources. With a geographic information system in place, Glacier is now positioned to employ remote sensing to monitor many of the more significant patterns. Symptoms of ecosystem stress that might be most cost-effectively addressed at the landscape scale include regressive succession and changes in gross or net primary productivity.

Some species of special concern to park management will be monitored at the population or subpopulation level. Special consideration will be given to species that characterize entire communities, enjoy special legal status, are endemics or aliens, or have a broad base of public support. In addition, species that are "keystones" (i.e., particularly sensitive to human disturbance), relicts or otherwise rare, or harvested may be monitored at or below the population level.

Glacier has established a significant inventory and monitoring foundation, and the park is ready to pursue subsequent phases of development.

Arctic Char Go Up Against Industry in Northwest Alaska

By Jim Petterson, Natural Resources Management Specialist
Northwest Alaska Areas National Parks

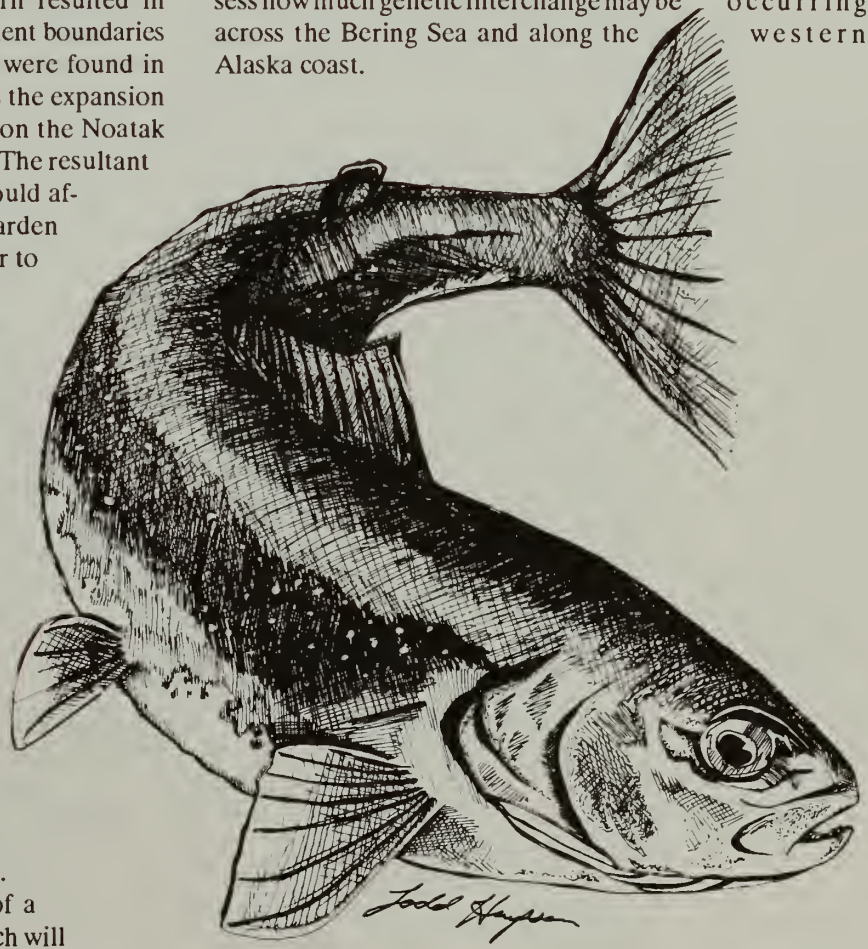
Some of the largest Dolly Varden char in North America occur in river systems within and adjacent to Cape Krusenstern National Monument and Noatak National Preserve in northwest Alaska. The char, which are an important food resource for several small Inupiat Eskimo villages situated near the monument boundaries, are being threatened by local industry.

Recent construction and operation of a lead-zinc mine immediately adjacent to Cape Krusenstern resulted in contamination of a river just outside monument boundaries and increased heavy metal concentrations were found in the fish. An additional threat to the char is the expansion of an experimental chum salmon hatchery on the Noatak River to a 60 million egg per year capacity. The resultant larger oceanic commercial salmon catch could affect populations of anadromous Dolly Varden char through higher incidental harvest prior to their return to river spawning grounds.

In order to keep tabs on population changes, the National Park Service and the Alaska Department of Fish and Game initiated a cooperative inventory and monitoring program to identify important spawning habitat and estimate numbers of returning fish. Aerial surveys were conducted over a three day period in August 1990 during the peak return of spawners. Major river systems and their tributaries were flown at low altitude, and numbers of fish were counted and locations mapped. Counts in various tributaries ranged from 386 to 2,802 and previously unknown spawning areas were identified.

Based on the results from this project, further studies are under consideration. One project could involve construction of a weir on one or more of the tributaries, which will be used to obtain important data on escapement and production of Dolly Varden. These baseline data are essential to assess possible impacts to char populations resulting from the hatchery.

Dolly Varden char tagged in a river adjacent to the park areas were recovered in 1989 and 1990 from a major river in the Soviet Union approximately 700 miles away. This has prompted interest in an international study involving more tagging efforts and genetics work to establish the degree to which char stocks may be distinct and to try to assess how much genetic interchange may be occurring across the Bering Sea and along the western Alaska coast.



Where Have All the Abalone Gone?

By Gary E. Davis, Research Marine Biologist, Channel Islands National Park

For nearly 10,000 years, fishermen and sea otters harvested the abalone in California for food with little effect on the population. Even as a modern fishing industry developed around the highly prized marine snail, populations remained stable. In the 1950s and 60s, commercial abalone divers hand-picked about 2,000 tonnes a year, supporting a lucrative and important addition to the U.S. fishery industry.

Then, in the 70s, coastal pollution reduced abalone stocks along the southern California mainland coast to virtual extinction. By 1980, when Channel Islands National Park was established, the only viable abalone populations in southern California were on the offshore islands. Five of these islands are part of the park.

These abalones in Channel Islands National Park are managed by the State of California, but the National Park Service is responsible for monitoring abalone populations and for making recommendations regarding protection. In 1981, the National Park Service initiated monitoring protocols for kelp forests and rocky intertidal communities, both of which contain abalone.

Monitoring data showed that between 1985 and 1990, abalone populations in the park declined by more than 95%, and juvenile recruitment was negligible. Commercial harvest dropped to one tenth of the level documented in the 1950s and 60s.

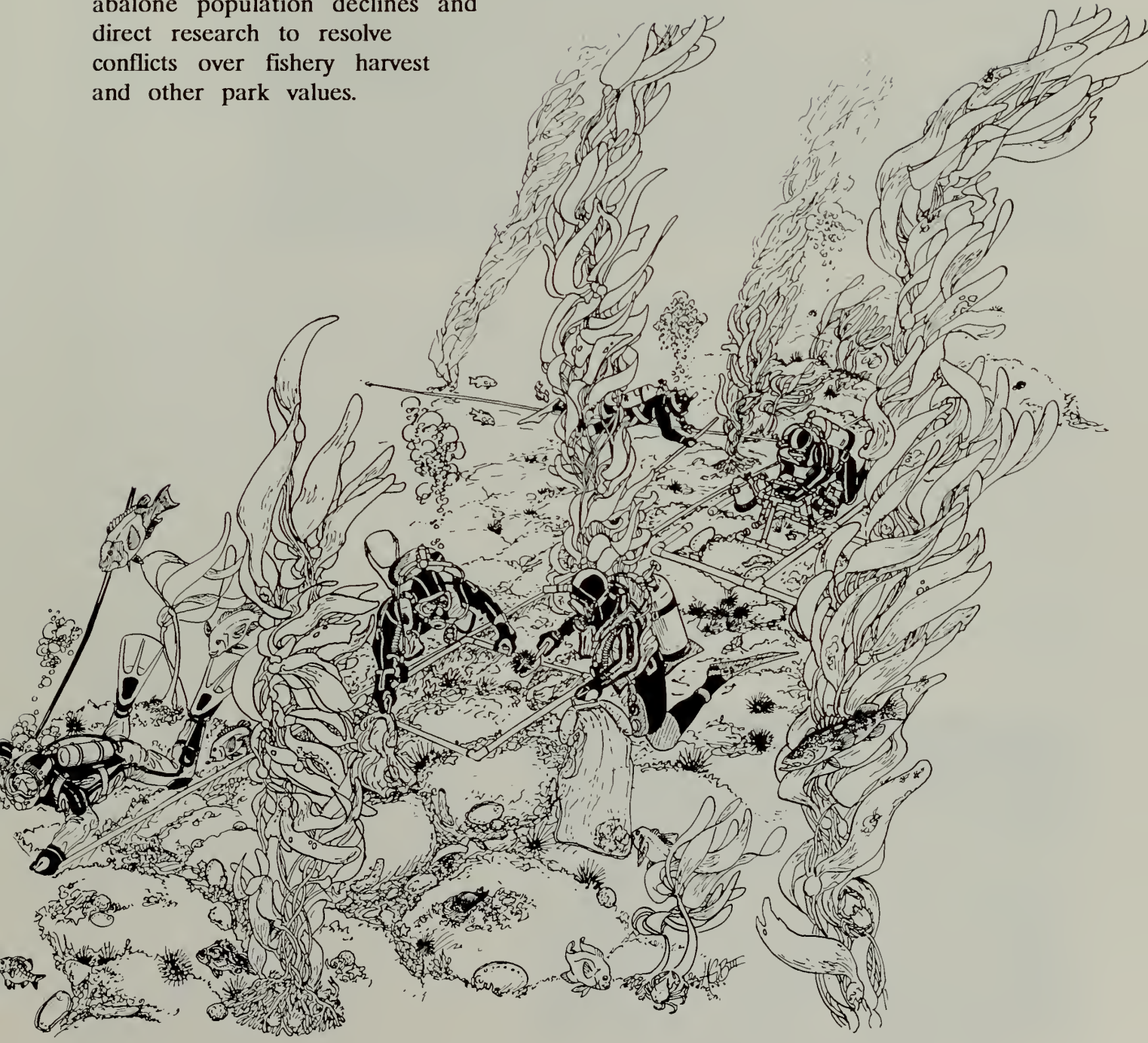
As a result of this monitoring program, park staff were the first to identify the nature and extent of this dramatic drop in population. The data also helped frame questions about potential causes and solutions. Continued National Park Service monitoring reports of collapsing abalone stocks formed the basis for cooperative research strategies developed by National Park Service scientists and those from the California Department of Fish and Game and the University of California. These investigations ruled out pollutants (heavy metals, DDT, and PCBs) and cast doubt on the hypothesis that disease or parasites were the root causes of the population crashes in the Channel Island populations.

Questions also remain on the role of fishery harvest in altering abalone reproductive capacity and success, especially in the face of extreme natural environmental variations like the 1982-83 El Niño event. National Park Service and California Fish and Game cooperative research on abalone recruitment in the park suggests that even though abalone spawn annually, successful juvenile recruitment is normally a rare event, occurring only once every 5-8 years. Consequently, traditional fishery constraints designed to protect reproductive capacity by setting minimum sizes of abalone for harvest may not work. Harvest refugia which protect ecologically-defined management zones may be required to sustain abalone fisheries.

The park's resource information also prompted local recreational divers to successfully petition the state to cut daily commercial bag limits in half and to reduce the open season from 10 months to seven. Pending state legislation would further reduce commercial harvest capacity.

While the abalone crisis in southern California is not yet resolved, it demonstrates the value of a forward-looking resources monitoring program. The Channel Islands National Park program identified a serious problem, directed research to resolve the issue, and proposed a fundamentally new approach to marine resources management that may reduce impacts of fishery harvest on the ecological and scientific values of park resources. Harvest refugia may be the key to resolving conflicts between fishery and park values in more than 30 National Park Service coastal areas with commercial fisheries, as well as in Channel Islands National Park.

NPS resource managers monitor kelp forest ecosystem health in Channel Islands National Park. The managers document abalone population declines and direct research to resolve conflicts over fishery harvest and other park values.



Soil Crusts Sound Pollution Alarm

By Jayne Belnap, Biologist, Canyonlands National Park

Most parks are or will be affected by air pollutants in the near future. As more work is done on the effects of air pollutants on biological systems, it is becoming clear that even the arid ecosystems once thought safe can be affected by a variety of gaseous, dry, and wet pollutants.

For this reason, it is important that the Park Service develop means of monitoring the biological resources of arid land parks. Ideally, such a biomonitor would be a species or suite of species sensitive to a variety of pollutants and found in arid land park units.

Cyanobacterial-lichen soil crusts are proving to be such a system. These crusts cover most soil surfaces found in all arid land park units. They have no cuticle or other means to exclude most pollutants. In effect, they act as sponges in regard to most air pollutants. Studies examining the effects of different sources of air pollution on these crusts have been on-going since 1988. Work has been done in 13 park units, as well as in controlled laboratory experiments.

Results from these studies have shown that several physiological functionings of these crusts are sensitive to many different types of air pollutants. Simulated acid rain increased chlorophyll concentrations in crusts on substrates derived from gypsum, limestone, sandstone, and igneous rock. Effluents from a coal-fired power plant increased metabolic rates and chlorophyll concentrations while decreasing nitrogenase activity. Elemental analyses showed that increased sulfur levels in the cyanobacteria were significantly correlated with the physiological effects observed.

The crusts are also affected by pollutants. Transects done at Organ Pipe Cactus National Monument demonstrated that crusts are being fertilized along the southern border, presumably from agricultural activities located along that boundary. Urban pollutants from the Los Angeles, California, basin degraded chlorophyll in the crusts transplanted from Canyonlands National Park, Arches National Park, Bryce Canyon National Park, and Saguaro National Monument. Other work at Saguaro National Monument is directed at using crusts to determine if air pollutants are playing a role in the observed decline of the saguaros within the monument. Preliminary results indicate that areas with increased saguaro damage also show increased chlorophyll concentrations and increased nitrogenase activity.

The long-term implications of these effects on the crusts and the surrounding ecosystem is not known. Increases in chlorophyll concentrations and metabolic rates indicate that the crusts can be fertilized by various pollutants. Anthropogenic additions of compounds to natural systems can result in problems such as deficiencies in other nutrients and lack of cold-hardening, which causes freeze damage. Nitrogen fixation is very important in desert ecosystems as nitrogen is often a limiting nutrient, and anything that affects this system is of concern. Since the large concentration of nitrogen-fixing species may be a result of greater selective advantage for organisms that can fix their own nitrogen, it is possible that external additions of nitrates may change the floral composition of these crusts.

Since these cyanobacterial-lichen crusts are found in so many park units and are sensitive to many different pollutants, they can be extremely useful in detecting what may be unseen threats to the parks. They can also be used as an early warning system for park managers that pollutants with potential ecosystem impacts are coming into their parks. With this in mind, further efforts will be directed at exploring the sensitivity of these crusts to other pollutants, as well as documenting baseline levels of chlorophyll and nitrogenase activity in various park units.

Fibrous cyanobacteria surround sand grain "boulders" when magnified 90 times in a scanning electron micrograph.

This 25 million year old small dog was found in the John Day formation.

Searching for Treasures at John Day Fossil Beds

By Ted Fremd, Curator, John Day Fossil Beds National Monument

Over 30 parks, monuments, and recreation areas in the National Park Service contain scientifically significant fossils. Many of these fossil assemblages are contained in material that weathers rapidly, endangering important fossils.

To avoid this potential loss, John Day Fossil Beds National Monument in Oregon has established a cyclic prospecting schedule. The principal rock formation in John Day is a hardened fossil soil horizon interbedded with volcanic ashes and claystone, both of which are particularly erodible. The John Day formation contains 20 families of mammals that are over 25 million years old. Each set of rock exposures is inspected every four years, a time period based on estimates of weathering.

As a result of having had a cyclic prospecting schedule in place, a number of specimens were discovered and stabilized in 1990 that would otherwise have been lost. These include one of the largest and most complete rhinoceroses known from this time interval, an excellent entire skull of an early small dog, and a variety of well-preserved small mammals, including rabbits and beaver. These fossils are noteworthy because they represent important niches of an ecosystem that has changed through time, demonstrating a gradual change to a cooler, drier climate in the Northwest.

Analyses of the fossilized soil profiles, abundant plants, and rapidly evolving animal fossils suggest that the present day environment of the northwestern United States is a short-lived interval preceded by a sequence of changes in the ecosystem. Several of these changes appear to have been catastrophic, with abrupt extinctions followed by gradual recovery of species diversity. This recovery resulted both from the evolution of new species and from immigrations from Asia and South America.

Continued study of these and other fossil communities promises to expand our knowledge of global change over a greater extent of time. A regular inspection procedure in parks with important fossils will ensure that these materials are retrieved from the field and placed into a museum collection, where they will be available for study.

International Park Resource Management Issues

How has the National Park Service Gained from Acid Rain Research?

By Jill Baron, Research Ecologist, Water Resources Division

The National Acid Precipitation Assessment Program (NAPAP) was authorized by Congress in 1980 to quantify and understand the causes and consequences of acidic atmospheric deposition. This ten-year, approximately 500-million dollar, multi-agency effort culminated in 1990 with delivery of 34 volumes of State of the Science and Technology Reports to Congress.

Among the myriad findings of this gigantic program is that acidic deposition does indeed cause acidification of sensitive aquatic ecosystems and can affect soil fertility. Relatively few aquatic ecosystems have been affected overall in the eastern United States, and none in the western United States. A very important finding is that acidification of lakes and streams can be reversed, although this cannot be construed as license to continue uncontrolled emissions of nitrogen and sulfur oxides. NAPAP research also found acid deposition in conjunction with other air pollutants and climatic fluctuations to be harmful to forests, and the mechanisms through which damage occurs are not simple.

The National Park Service participated in NAPAP in several ways. The Park Service received direct NAPAP funds to conduct watershed-scale research in sensitive but relatively unaffected remote areas of the West and Midwest. Support was also provided for 16 park areas to participate in a nationwide, long-term monitoring network, the National Atmospheric Deposition Program/National Trends Network, to detect and measure levels of acid precipitation. The National Park Service Office of Historic Preservation was involved in research into the effects of acid deposition on man-made materials. Park Service scientists teamed up with other investigators both inside and outside of parks to avoid duplication and maximize expertise. Some park areas allowed outside researchers to come in and conduct research without active park involvement.

This is a good opportunity to look back and evaluate the benefits to the National Park Service from this ten-year program. What did we gain? Did we lose anything? As we embark on a new multi-million dollar, multi-agency program, this time related to the effects of global change, what lessons can we apply, what pitfalls can we avoid?

The National Park Service benefitted from NAPAP involvement in many ways. There is the absolute information learned about deposition chemistry, surface water sensitivity, forest responses, and ecosystem processes in many park areas. For the most part, these data were collected and evaluated rigorously, with an unprecedented degree of quality control. We can now undertake a ranking exercise to identify parks with damaged resources, parks at risk, and parks not at risk from acid deposition. Regions can now, if they have not already done so, devise strategies for addressing the effects or the potential for effects. To paraphrase C. S. Holling, we have reduced the possibility for surprise with respect to acid rain.

In the long run, the intangible benefits to the Park Service from participation in NAPAP will be just as important as the acquired body of knowledge about natural resources. During the ten years of NAPAP we have built up a core of experienced, respected researchers capable of addressing the interdisciplinary issues that characterize natural resource management today. We have become members of a multi-agency and multi-university cadre of scientists also addressing these complex questions. This is particularly important at a time when natural resource problems continue to expand across boundaries. Parklands are not immune from outside influences, and cannot be managed as if "apart" from the external world. Acid deposition is regional to continental in scope. Park scientists cannot address its sources and consequences alone, and our involvement with NAPAP has opened the doors for the necessary collaboration. NAPAP has shown us that we must work ever more closely with national and international natural resource communities to devise collective management strategies.

Another post-NAPAP legacy is the recognition of additional responsibility for Park Service lands. National parks have intrinsic scientific and environmental value as barometers of change. The burden on the Service is to not only maintain park areas in as natural a state as possible, but to also provide the records of environmental behavior over time.

What are the lessons we can apply beyond NAPAP? Most importantly, acid rain research has taught that there

is no substitute for long-term records. Natural resources under our stewardship are subject to local, regional, and now global-scale disturbances. It is only through the understanding obtained from long-term observation that we can hope to sort out these disturbances and take the appropriate management action. Long-term records are invaluable tools for evaluating local and regional permit applications for new emission and other disturbances. Coupled with models, these records can be used to predict the potential for ecological change. Long-term records can also be used to evaluate the effects of man-made pollutants over time by allowing comparisons of natural variability with observed variability into the future.

There is another lesson. NAPAP required annual interagency reviews of our programs to evaluate the strength of the science, the progress toward goals, and the significance of National Park Service research within the larger, national program. This approach produced high quality results, and it should be adopted by all other research and monitoring programs sponsored by the Park Service. It also should be vigorously applied to all outside researchers intending to use National Park Service lands for their studies.

Overall, the National Park Service's participation in NAPAP has been positive. The past ten years have prepared us better than ever for the challenges of attempting to manage natural resources in a variable world.

NAPAP Summary

By Mark A. Scruggs, Chief, Research Branch, Air Quality Division

In general, the NAPAP assessment was that there may be significant effects due to acid deposition in isolated geographic areas, but that a serious widespread threat did not exist.

The draft assessment identified the following specific effects that NAPAP researchers asserted were clearly associated with acidic deposition and related air pollutants.

- Adverse effects to aquatic communities in about 10% of eastern lakes and streams. Adverse aquatic effects are probably higher if acidic episodes occur.
- A reduction in visibility throughout the eastern U.S. and in some large metropolitan areas of the West.
- A contribution to the current rates of erosion and corrosion damage to stone and metal structures and cultural resources.
- A reduction in cold tolerance of red spruce trees at high elevations.

Examination of emissions and deposition data and research data also demonstrated the following.

- There is a strong correspondence between high sulfur dioxide emissions and high sulfate deposition.
- Oxidants, nitrogen oxides, and volatile organic compounds contribute to non-linear transformation of sulfur dioxide to sulfate.
- There are significant benefits to be realized by achieving emission reductions through control of existing sources over the next thirty years, rather than relying on reductions achieved by the gradual retirement of overage facilities.

For the immediate future, the National Park Service plans to continue precipitation chemistry monitoring and participation in the National Atmospheric Deposition Monitoring Program, and also the watershed research program to the extent that resources permit. In November 1990, Congress re-authorized NAPAP, but the details of National Park Service involvement and the implications for research and monitoring activities are not yet determined.

Global Change Research in National Parks

By David N. Figlio, Global Change Program Assistant

Throughout the earth's history, mean global temperatures have increased and decreased, shorelines have changed, and climatic patterns have varied. Over the past century, however, studies indicate that the earth is experiencing a gradual warming trend and the current changes seem to be occurring at a pace 10 to 60 times faster than any previously recorded climate change.

Although the potential for increased average temperatures is a source of concern, the other climatic changes which could accompany higher temperatures pose potentially greater problems. Changes in the frequency, scope, and intensity of other climatic "events," such as droughts, storms, and wildfires, could be much more difficult to manage than high temperatures. This uncertainty about the future presents significant obstacles to the decisionmakers and managers charged with the stewardship of our natural resources.

It is this potential threat to national park ecosystems and natural and cultural resources which makes global change research essential. Research data can help resource managers to better understand the changes occurring in the areas they manage and will assist in making policy decisions necessary for dealing with the affected resources.

Several factors make national parks attractive sites for global change research. The minimal history of disturbance has left intact large tracts of land encompassing significant portions of natural ecosystems. This lack of disturbance makes it easier to separate global change effects from anthropogenic disturbance. The large scale of these areas facilitates the landscape and regional level studies necessary to comprehensively study global change. In addition, the existing baseline data already available in many parks can provide crucial information on which to build the required long-term data bases for global change research.

In order to study global change on a national level, the National Park Service is using a biogeographic area approach. A biogeographic area is a landscape-scale area based on the biosphere reserve model. Many prospective partnerships have already been developed with other federal agencies, universities, and private institutions utilizing this biogeographic area structure.

In FY 1991, the National Park Service and cooperating researchers are beginning work on 14 research projects in six biogeographic areas--the Colorado Rockies, the Glacier National Park Area, the Olympic Peninsula, the Ozark Highlands, Southern and Central Sierra Nevada, and the Western Lake Forest. Research commenced this year includes studies of tree rings, aquatic ecosystems, nutrient cycling, pollen analysis, fluvial geomorphology, fire history, and forest demography, as well as development of forest succession, regional, and landscape-level models. In the future, as more areas launch research efforts, additional research will be initiated.

The following articles discuss two of the biogeographic areas participating in the global change research program.

The Ozark Highlands

By Gary Willson, Ecologist,
Midwest Regional Office

The Ozark Highlands stretch from the Boston Mountains of northwest Arkansas and eastern Oklahoma to the Springfield and Salem Plateaus of Missouri, covering an area the size of Florida. In the Highlands, two major ecological zones meet, the tallgrass prairie and the western edge of the eastern deciduous forest biome. The area contains miles of riverways, including the Ozark National Scenic Riverways, the Buffalo National River, and riverways in the Ozark National Forest.

Because of these unique ecological features, this region is under consideration as a biosphere reserve. It has also been targeted by global change models as a geographic area that will be significantly affected by global climate change. For these and other reasons, the area has been selected as a global change research site.

The Ozark region is an excellent laboratory for the study of global change effects. The region contains a substantial record of paleoenvironmental history, which provides a basis for developing and testing models of how environmental conditions might change with changing climate. Tree-ring analysis of red cedars has shown the potential for climatic reconstruction in Missouri for the last 500 years or more. Also, the spring and summer minimum discharge of Ozark streams is highly correlated with red cedar ring widths. This relationship offers an opportunity

to reconstruct the flow of Ozark streams for at least the last 500 years. Palynological investigations of a peat deposit from a small sinkhole bog and two archeological sites at Ozark National Scenic Riverways provide a vegetational record for the last 3,100 years in the southeast Ozarks. Finally, cave deposits from the numerous caves of this karst region can be used to develop long (>150,000 years) paleotemperature records for the Ozarks.

The Ozark Highlands climate change program will concentrate on aquatic resources. In the early 1970s, both parks began comprehensive water quality studies to determine the physical, chemical, and biological conditions of the ground, spring, and surface waters. This information constitutes a baseline for comparison with projected future conditions influenced by a warmer and drier climate.

Although the program will emphasize aquatic studies, other resources are potentially sensitive to climate change. The glades of the Ozark National Scenic Riverways and the Buffalo National River are unusual grass-dominated ecological systems embedded in a forest matrix. The interfaces between the glades and the landscape matrix of forests are some of the most dynamic and climatically sensitive ecological systems in the Ozarks. Also, visitor use and perceptions data has been gathered at the Ozark National Scenic Riverways since 1972, and a river use monitoring system was initiated that year. The monitoring program could be expanded or adapted to meet future objectives with regard to social and behavioral consequences of climate change.

Invited research proposals for the first year of the Ozark Highlands program include funding and/or staff contributions from the U.S. Geological Survey and the Fish and Wildlife Service, as well as the University of Arkansas, the University of Missouri, and Iowa State University. A coordinator for the Ozark Highlands will be stationed at the Fish and Wildlife Service Cooperative Fish and Wildlife Research Unit at the University of Missouri, Columbia.

Glacier National Park

By Kathy Dimont, Research Assistant and Geographer, Carl Key, Glacier National Park

Scientific evidence indicates that the earth may be entering a period of rapid climate change. Compounds being released into the atmosphere may be influencing chemical and physical processes around the world. In the atmosphere, "greenhouse" gasses such as carbon dioxide, methane, and chlorofluorocarbons permit passage of incoming solar radiation, but trap radiant heat reflected back toward space. If the planet is warming at the rate estimated, all living things will be affected, but neither the capacity for rapid adaptation nor tolerance levels for change are known.

The Glacier National Park Biogeographic Area provides an ideal setting to test climate change hypotheses. The geographic location, topographic features, and prominent ecotones allow the study of ecological processes that influence composition, distribution, and migration of biotic communities. Regional land use practices around the protected park area can be monitored to differentiate between human disturbances and those attributable to climate shifts.

Landscape analysis will be applied to study relationships between climate change and plant community response. The long-term nature of landscape research requires an approach that compares past, present, and future conditions. Data describing past and present landscape conditions constitute the baseline. Through accurate mapping, current rates of change can be estimated. The construction of models that predict future biotic response to climate change scenarios is a research priority.

When these models are compared to current maps, an assessment of potential effects can follow. Although direct cause-effect relationships cannot be proven quickly enough for immediate forecasts, the construction of models that predict the response of floral and faunal communities to future climates provide thresholds of expected change. The terrestrial communities most sensitive to climatic conditions are expected to exhibit the first signs of change.

Since alpine communities have evolved and persist today under severe temperature and moisture stress, they are likely to respond quickly to subtle climate changes. On the other hand, since present day alpine communities have already survived limited postglacial warming, they may adjust to projected climate changes with minimal stress, depending upon the rate of change.

In either case, proximity of both fragmented and intact habitats will provide ample opportunities for research in insular ecology. Treeline environments and other ecotone communities will receive special emphasis along with species existing at or near the southern limit of their range.

An understanding of postglacial climates is requisite to predictions about future climates. The important difference between known prehistoric climate changes and those now predicted is the rate at which changes are likely to occur in the future. Statistical projections indicate that rapid warming will be accompanied by an increase in the frequency and intensity of weather events. Ecosystem models will provide a strategic framework for understanding rapid climate change and its effects.

INFORMATION MANAGEMENT MEETS RESOURCE MANAGEMENT

GIS Finds a Place in the Parks

As recently as 1987, only four parks had operational geographic information systems (GIS). By the end of 1990, that number had increased to 40, and more parks come "on line" daily. The National Park Service began using GIS technology in the mid-1970s, seeing the advantage of a computer program that allowed cartographic overlaying of resource data to highlight resource interactions. The technology was originally located in the Denver Service Center. The focus was on the use of remote sensing data to derive project-specific resource information for analyses. This information was often used only for the project at hand.

As the use of GISs grew, the Park Service recognized the value of the technology for individual parks. The GIS function was moved from the project-funded program at the Denver Service Center to the Park Service's base-funded natural resources program in 1984. The use and application of GISs expanded rapidly. In 1990, efforts were initiated to expand the use of GISs in a systematic and efficient manner. Regional GIS plans that prioritize projects were begun and, with the strong support of the Director, a three-fold increase in funding was obtained for FY 1991.

In the space of four years, the Park Service has increased the number of parks using GIS by 1000%. The technology has been expanded from a limited use to a Servicewide technology, and the possibilities for resource management are practically limitless.

GIS Highlights at Yosemite National Park

By Jan van Wagtendonk, Fire Ecologist, Yosemite National Park

This year saw the beginning of a transition of the Yosemite geographic information systems (GIS) program from research and development to operations. Research uses continued with analyses of great gray owl habitat and the spatial distribution of lightning strikes. Operations uses included the investigation of alternative housing sites and assistance in the suppression and evaluation of the 1990 Yosemite fires.

The great gray owl study combined meadows and surrounding forest vegetation information with elevation information to determine which meadows were suitable nesting habitat. Maps generated by the GIS were then used to direct field crews searching for additional birds. This survey resulted in a doubling of the number of known owls in the Yosemite region from 26 to 52.

The lightning strike analysis showed that the over 9,000 strikes occurring in Yosemite between 1985 and 1989 were significantly affected by elevation, but not by slope or aspect. Some disproportionate distribution was attributed to watershed as an indicator of geographic variation. Lightning probability maps were developed from the data.

In order to assess all potential sites for replacement housing in Yosemite Valley, GIS layers of slope, elevation, roads, and wilderness were combined. The resulting map showed all non-wilderness areas over 30 acres that were not more than 45 minutes away from the Valley, two miles from an existing road, or within 1,000 feet in elevation away from a road. This map was then displayed with archeological sites, sensitive plant habitats, great gray owl nesting and staging areas, spotted owl habitat conservation areas, and fire hazard zones to locate areas with constraints on potential development.

The large Yosemite fires provided an opportunity to use the GIS in a real-time basis for fire planning, operations, and post-fire evaluation. Upon arrival in the park, incident command teams were provided with maps of fuel models, slope, vegetation, and previous prescribed fires and wildfires. These were used in the initial planning and fire behavior predictions. Fire perimeter and area maps and calculations were provided on a daily basis as soon as thermal imagery was interpreted and digitized. After the fire was suppressed, the GIS was used to assess debris flow hazards by comparing a map of the severity of burn with watershed, surface geology, slope, and ownership maps.

The Yosemite GIS has proved to be an extremely helpful management tool as well as an essential part of the park's research effort.

Voyageurs Predicts Impacts to Mammals

By Gary Sullivan, Biological Technician,
Midwest Regional Office

The name of Voyageurs National Park evokes images of countless lakes and streams teaming with fish and the furbearers which originally drew the "voyageurs" to this territory in Minnesota.

Unfortunately, this image is false. At the time of the park's establishment in 1975, resources had already been significantly changed from those seen by the first "voyageurs." Impacts had accumulated from artificially regulated lake levels, fire suppression activities, game and timber harvesting, and unchecked recreational use. The result was an environment very different from pre-European conditions.

To better understand and properly preserve the remaining resources, Voyageurs' and the University of Minnesota are developing a geographic information system (GIS) data base to document current conditions and predict successional trends in plant and animal communities.

A portion of this cooperative effort is focused on predicting the effects of human influence on moose population densities in two separate areas in northern Minnesota, Voyageurs National Park and the LaCroix district of Superior National Forest. In conjunction with the University of Minnesota, the park is developing and field checking a detailed GIS data base using GRASS (the GIS software recommended by the Park Service) that will be used to evaluate two habitat suitability indexes. These indexes attempt to identify and ascertain suitability ranges for several critical variables associated with food supply, cover, water, and spatial needs of moose. This will allow a more accurate prediction of human influence on moose populations both inside and outside the park.

Another animal population being studied with the help of the GIS is one of the most influential mammals in Voyageurs. The population of the beaver was severely decimated by human activities previous to park establishment. Once on the brink of extirpation, this mammal has shown a remarkable recovery. Recently, researchers at the University of Minnesota used a GIS data base to analyze how beaver have altered the hydrology and vegetation of Voyageurs over the 46 years of population recovery. Aerial photographs and a raster-based GIS provided data on impoundment hydrology and vegetation distributions for 1940, 1948, 1961, 1972, 1981, and 1986. Hydrologic and vegetative changes were quantified using overlay and classification techniques.

The researchers found the GIS superior to manual methods of area measurement and crucial to analyzing transition areas. Beaver populations were estimated to have increased from near extirpation to 1 colony/km^2, while the total area impounded increased from 1 to 13 percent of the landscape. The data base developed in this research will be converted to GRASS format so that it can be incorporated into the park's GIS data base.

Using this same GIS database, researchers have been able to predict beaver colony density. Beaver impoundments were located, mapped, and classified according to impoundment type. The Earth Resources Data Analysis Systems GIS facilitated data description, manipulation, and analysis. The Minnesota Department of Natural Resources' annual aerial cache count supplied a population index of active beaver colonies/km of survey route. Researchers performed a stepwise multiple regression of the number of active beaver colonies against the area of impoundment habitat variables for the six dates of photography (1940 - 1986). From the regression model, two habitat variables--shallow marsh and seasonally flooded meadow--were chosen as the most appropriate predictors of beaver colony density. These models can be used in wildlife management and research to estimate historical beaver populations and assess the effects of beaver on aquatic and terrestrial ecosystems.

Shenandoah Changes Its Point of View

By David Haskell, Resource Management Specialist, Shenandoah National Park

One of the primary visitor activities in Shenandoah National Park is enjoying the spectacular views of the Blue Ridge Mountains and the Shenandoah Valley from the many Skyline Drive overlooks and mountain peaks. In many areas of the park these views are being lost or threatened by rapid changes in land use. The protection of these views has become a major element of Shenandoah's new related lands program, one of the three new geographic information system (GIS) land themes, or resource mapping layers, added to Shenandoah's GIS program this year.

The total area both inside and outside of the park that is visible from each of the identified 80 key viewpoints is defined as the park viewshed. Using GIS capabilities, the park's viewsheds were defined and mapped. Each viewpoint was digitized and the angle of possible view measured. Defense Mapping Agency digital elevation data was used to do the viewshed analysis in GRASS (the GIS software recommended by the Park Service), determining areas that could be seen from each of the plotted points. Individual analyses made for each of the viewpoints were combined and laid over the park map. The final product is a map and data base of the park and surrounding landscape (approximately 12 km beyond the boundary), color coded to show from how many points the landscape can be seen. As an example, the areas depicted in red represent those that can be seen from ten or more viewpoints.

The viewshed theme has already been used extensively by park staff for various analytical purposes. The first application supported the National Park Service's review of proposed county landfill sites. A county adjoining the park had selected several alternative sites for the construction of a new landfill, several of which were potentially within the viewshed. In only a few minutes, the most desirable site was chosen based on relative visibility from the park. The viewshed theme will be used extensively in the development of the park's related lands program to help determine which properties outside of the park have the greatest value for sustained protection from adverse types of developmental change.

A second major GIS land theme developed this year is related land use. Image analysis performed by the GIS Division in Denver identified five basic land use classes: forest, agriculture, urban, barren, and water. Although an overall accuracy rate of 79% was achieved, additional refinements are necessary to increase the accuracy rate of the barren category. This will greatly increase the overall accuracy of the map. Largely because of the 20 meter cell size (approximately 1/10 of an acre resolution), not all of the single homes that exist in the mapped area have been recognized. Small dwellings are being hand digitized from aerial color infra-red photography for those locations where the data base appears to be incomplete. This data base will serve as the land use inventory and will be updated at regular intervals to track land use change. The related land use theme, overlaid with other existing themes, is used analytically in the related lands program to identify critical habitat, wildlife travel corridors, areas of outstanding visual quality, and key public access locations.

The third new GIS theme is land ownership. This theme is also being prepared to support the related lands program, but will have other uses. The data base being compiled from county land records includes basic information on parcel size, the name and address of the owner, and the existence of any easements and restrictions. This data base will be referenced to the map theme containing the boundaries of all land parcels that have a common boundary with the park or that are within 1000 meters of the park boundary.

GIS is Everywhere in the Everglades

By Michael Rose, Remote Sensing Specialist, Everglades National Park and
Frank Draughn, GIS Specialist, Everglades National Park

As natural resource management becomes a more complicated task, the value of integrating scientific data into management decisions increases in importance. In the South Florida Research Center of Everglades, which is responsible for addressing the research and resource management needs of south Florida, the geographic information system (GIS) using GRASS (the GIS software preferred by the Park Service) is quickly developing into the management tool of choice.

Hydrology Everglades wetlands are very sensitive to water quality perturbations and require nearly pristine water for the preservation of ecological integrity. Reports indicate that over 30,000 acres of native Everglades wetlands have already been destroyed due to the introduction of nutrient-rich polluted water from upstream agricultural lands. GRASS-GIS is being used to produce models and maps identifying the current degraded water quality impact areas.

The Shark River Slough provides the major sheet flow of freshwater supplying Everglades National Park. A spatial and temporal study is determining the rainfall component as it relates to hydrological stage. Hydrological data are input into GRASS-GIS and used to model rainfall, surface water, and ground water patterns for creating a set of baseline data to be used for all future research projects.

Wildlife Management The number of wading birds in the Everglades system declined by an estimated 90% between the 1930s and the 1980s. In order to investigate this alarming decline, a research project was initiated in 1983 to determine the status of these birds and the environmental characteristics which control their distribution and abundance. Systematic reconnaissance flights were performed monthly over the park to determine the numbers of birds in the park by species, distribution, and associated water conditions. GRASS-GIS analyses were performed to predict the possible impacts on the birds from alterations to the water management systems of South Florida. Similar systematic reconnaissance flight survey and GRASS-GIS techniques are also being used to investigate alligator nesting and deer populations within the park.

Endangered Species A Florida panther population estimated at 30-50 individuals still exists in the cypress swamp, pine forest, and sawgrass ecosystems of the Everglades. A cooperative research project is underway to radio-collar panthers and monitor them daily by fixed wing aircraft and ground vehicle. The geographic location monitoring data has been entered into GRASS-GIS to identify critical habitats and document animal interaction.

The American Crocodile has a very small population in the Continental United States. It requires brackish lakes and marshes in the subtropics and tropics. The southeastern panhandle area of the park is a part of this last remaining critical habitat. GRASS-GIS was used to locate these areas and produce a number of graphics for reports. Park management now has limited access to these areas.

Vegetation Management Exotic plants are invading thousands of acres of native sawgrass prairies in south Florida. This creates incredible management problems for Everglades National Park. Some exotic plants are fire-adapted and cause severe fires that interrupt the natural fire regime. Some invade critical habitat for endangered species and cause loss of habitat. Aerial photography and GRASS-GIS are being used to identify exotic plant populations and target them for chemical treatment crews.

In an effort to reclaim critical habitat for endangered species, the park has developed a pilot project to remove exotic plants and restore native wetlands. GRASS-GIS is being used for three-dimensional topographic and hydrologic modeling across the restoration sites.

Fire Management A critical ecological factor in the Everglades is fire. Fire history data has been collected on fixed wing aircraft and rotorcraft reconnaissance missions. Previously, all of these data were stored on USGS quadrangle maps in map files. A large project was organized to digitize 10 years of fire history data into GRASS-GIS. This data conversion process is now complete and Fire Management is incorporating GRASS-GIS into their long-term planning strategies and their short-term wildfire emergencies.

SPECIAL HABITAT FOR SPECIAL SPECIES

Rarest U. S. Wolves Return to Great Smoky Mountains National Park

By Bob Miller, Management Assistant, Great Smoky Mountains National Park

The red wolf is one of the most critically endangered mammals in the United States, despite their success at breeding in captivity. The historic range of the red wolf included most of the southeastern United States, but by 1970 the animal had been virtually eliminated by predator control programs and the conversion of forests to agriculture. Following the passage of the Endangered Species Act in 1973, the U.S. Fish and Wildlife Service captured the 40 remaining wild red wolves in order to prevent their complete demise. The population has since risen to 135, but that is not high enough to ensure population stability.

In 1989, a draft red wolf recovery plan recommended that to ensure the long-term survival of the species, the population should be further increased through controlled breeding to a total of 550 animals. Of these, approximately 330 should remain in captive facilities, and 220 should be wild-ranging in at least three separate populations. Based upon criteria in the recovery plan, the Great Smoky Mountains National Park was selected as the most promising reintroduction site.

After almost a year of planning, the park and the Fish and Wildlife Service announced plans to explore the reintroduction of the red wolf to the Smokies in April 1990. The first wolves will arrive in the park in January 1991. One wolf pair and their pups are scheduled for release from their acclimation pens in August 1991.

Long-term survival of the red wolf in the Smokies faces some major obstacles. The greatest biological threat to a successful reintroduction is the possibility of interbreeding with newly-arrived coyotes, which were first found in the park in 1985. In their last wild habitat, wolves had begun to interbreed with coyotes, which now occupy up to 90% of the wolf's historic range.

The first phase of the Smokies project is thus an experiment designed to assess this potential problem. The University of Tennessee is conducting a coyote census in the park using howling and scent post surveys and tracking coyote movements by telemetry. To date, only five coyotes have been trapped for collaring, and results of the other sampling methods indicate a relatively low occurrence of coyotes in the park. The first wolves released will be tracked for up to six months, and their interaction with coyotes evaluated. The decision to go forward with reintroduction will be based upon this evaluation.

Another threat to the recovery plan is the fact that reintroduction of a major predator often faces vigorous local opposition. In an effort to diminish public concern, representatives of the park and the Fish and Wildlife Service have been conducting a campaign to educate the public about the red wolf's history, social structure, and diet, and to explain and discuss plans to release and manage them. Meetings have been held with elected state and federal officials and with wildlife managers, conservationists, sportsmen, farm bureaus, livestock owners, and civic groups. These groups have been contacted individually rather than through formal public meetings. A new brochure and newsletter have been distributed, and, as the first releases draw nearer, a citizen's forum will be established to enhance communication between project managers and the interested public.

Public response has ranged from very supportive to a "let's wait and see" attitude. One neighboring county's livestock association is opposed to the project, but is eager to be involved in the forum. Press coverage has been very favorable, generally treating the story as a piece of good news on the environmental scene.

Butterflies Find Refuge at Biscayne National Park

By Thomas C. Emmel, Professor of Zoology, University of Florida and Richard W. Curry, Resources Management Coordinator, Biscayne National Park

The endangered Schaus Swallowtail is a large and colorful butterfly that is endemic to southern Florida. At the beginning of this century, it occurred from the Miami area south to at least Lower Matecumbe Key and perhaps even to Key West. It disappeared on the mainland of Florida after 1924, apparently because of habitat clearing. By 1984, the butterfly's range in the Florida Keys had been reduced to only three small keys inside Biscayne National Park and a single tiny colony outside the park on northern Key Largo.

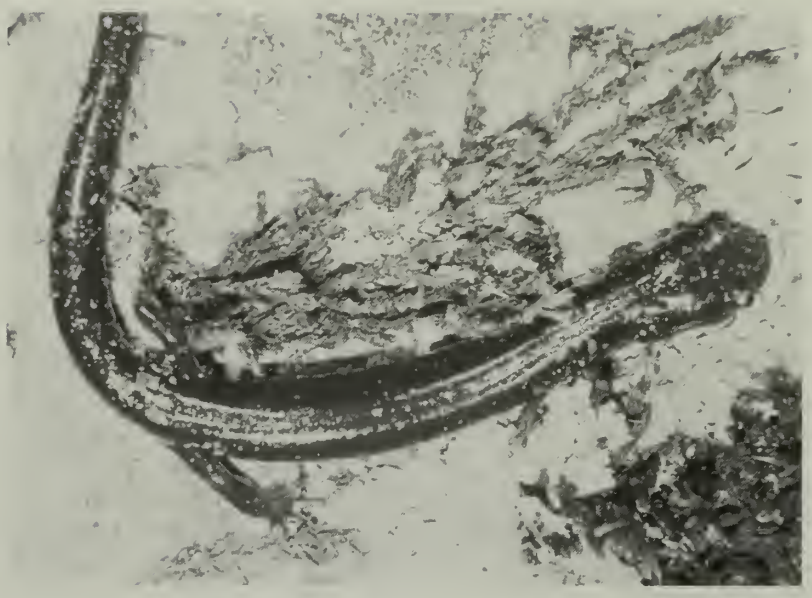
A research team from the University of Florida at Gainesville has been working with Biscayne National Park personnel from 1984 to 1991 to study the status and habitat requirements of this rare species. Using mark-recapture methods, the team studied population numbers, movements, aging, sex ratio, evidence of predator attack, and other features of the biology of the adult Schaus' Swallowtail. Field surveys were conducted throughout Biscayne National Park and the species' former range further south in the Florida Keys. The team mapped habitat, potential foodplants, and butterfly distribution and studied competitive species. Habitat conditions for the past 90 years were determined. Laboratory experiments identified the lethal effects of mosquito-control pesticides being sprayed throughout the Florida Keys outside the park.

Several important conclusions and management recommendations have been reached to date. Schaus' Swallowtail was found to be apparently a distinct species. The annual population levels of the Swallowtail have not substantially exceeded 1,000 adults in the past six years. The only sizeable populations are restricted to the keys within Biscayne National Park, where habitat and foodplants are still available. When mosquito control spraying was halted temporarily in late 1984-1987, the single tiny colony on Key Largo was able to expand to between six and eight colonies each year, apparently by recolonization from adults flying south out of Biscayne National Park. But in 1988, the local county mosquito control district resumed mosquito spraying on northern Key Largo and reduced the population outside the park to a single precarious colony again.

This data indicates that the endangered species classification should be maintained until Schaus' Swallowtail exists in annual numbers exceeding at least 1,000 adults outside Biscayne National Park. Annual surveys are being continued to determine trends in population status. Monroe County has been asked to cooperate in halting the spraying of mosquito adulticides in hammocks across northern Key Largo. Unless they actually comply with this request, the populations within Biscayne National Park will remain the last refuge of the species, providing the only potential source for reintroduction of Schaus' Swallowtail in the hammock areas suitable for colonization further south than the park.

The Last Stand of the Shenandoah Salamander

By Rick Potts, Natural Resource Specialist, Shenandoah National Park



In the Blue Ridge Mountains of Virginia, five populations of a lungless, terrestrial salamander are making a last stand. The Shenandoah salamander survives in three high elevation areas of the Shenandoah National Park. In 1989, the salamander was added to the federal list of endangered species.

The Shenandoah salamander is closely related to, and easily confused with, the much more common and widespread red-backed salamander. All lungless salamanders breathe through their delicate skins and the linings of their mouths. The Shenandoah is a slender, moderate-sized salamander. The body is dark brown, with two color phases. The striped color phase has a narrow red to yellow stripe extending mid-dorsally from the head onto the tail. In the unstriped phase this stripe is absent and the back is uniformly dark brown, but a variable number of small reddish spots may be present down to the middle of the back.

The population densities within the range of the Shenandoah salamander are unknown, and it is not certain if the range is stable, expanding, or dwindling. It is found mainly on north to northwest facing talus slopes at elevations above 900 m (3,000 ft). The preferred microhabitat areas are small islands of soil and organic deposits interspersed among talus rock formations.

The Shenandoah salamander may be threatened by competition and hybridization with the red-backed salamander. The salamander also faces potential threats in the form of gypsy moth defoliation and possible tree canopy thinning, which can decrease the moisture content of the forest floor through dessication. Acid deposition in the form of rain, snow, and fog, and the resultant low soil pH, is also known to have detrimental effects on young terrestrial salamanders. In addition, due to the observed occurrence of these animals only in the coldest areas of the park, it is reasonable to assume that their continued existence would be jeopardized by any increase in temperature brought about by global climate change.

Research has shown that some hybridization is taking place. Further studies will be conducted if the threat of gene swamping appears sufficiently great to warrant additional collecting. In consultation with the U.S. Fish and Wildlife Service, the park elected to protect the critical habitat of the Shenandoah salamander against defoliation by gypsy moth by aerial application of the biological insecticide Bacillus thuringiensis (Bt). Limited experimentation was conducted in 1990 to compare the effects of defoliation versus the effects of Bt treatment on the salamander. Pre- and post-treatment population surveys analyzed for treatment effects indicated no differences.

In 1990, a salamander management workshop attended by subject matter experts and representatives from management agencies was conducted to review what is currently known about the Shenandoah salamander, identify needed information, and develop possible monitoring and research designs to provide this information. Efforts will continue to locate new populations and further delineate the boundaries of known locales. Additional research concerning interspecific competition between the Shenandoah and the red-backed salamander is being planned. The method under consideration would not negatively impact any Shenandoah salamanders. It involves depopulating an area adjoining an existing Shenandoah salamander population of all red-backed salamanders, then monitoring the recolonization and interactions of the two species. This study would also test the relative ability of each species to colonize and defend the best microhabitats, such as rotten logs.

Peregrines Come Back to the Rockies

By Mike Britten, Peregrine Falcon Recovery Coordinator, Rocky Mountain Region

In 1990, a pair of peregrine falcons nested successfully in Rocky Mountain National Park for the first time since the population crashed in the early 1970s. Captive-reared young peregrines have been released at a number of Rocky Mountain Region parks, and the production of wild pairs has been augmented through manipulation of eggs and young at others.

These efforts and successes are a result of the implementation of a comprehensive program for peregrine recovery in the Rocky Mountain Region. Although parks in the Rocky Mountain Region have been working towards the recovery of the endangered peregrine falcon since the late 1970s, efforts were inconsistent until the region received Natural Resources Preservation Program funding to develop a comprehensive recovery program.

The objectives of the Rocky Mountain Region program are to: 1) survey all potential habitat in the region; 2) monitor territory occupancy and productivity; 3) monitor reproductive health of the population; and 4) augment populations.

In the first two years of program implementation, substantial progress has been made. In addition to the releases mentioned above, surveys made to determine productivity levels have documented 55 occupied peregrine breeding territories which fledged 82 young. Productivity was 1.7 young per occupied territory. In contrast, in 1986, 24 territories produced 38 young. While the increased survey effort accounts for some of the change, there has clearly been a population increase.

The reproductive health of the population has improved as indicated by the increase in eggshell thicknesses from the late 1970s through 1990. Although still not at pre-DDT era thickness, eggshell thicknesses are getting closer to "normal."

In other research, the National Park Service has cooperated with the U.S. Fish and Wildlife Service in a study of organochlorine and heavy metal contaminants in peregrine prey. This work duplicates a study done in 1980 and will be completed in 1991. The Rocky Mountain Region has also developed a banding protocol for peregrines using aluminum color-coded bands. The color of the band indicates the general origin of the bird while a unique code identifies the specific origin.

In the final year of the program, unchecked areas will be surveyed, a large sample of eggshell fragments gathered and measured, additional young peregrines banded, and the prey contaminants study completed.

Information from surveys of peregrines in the Rocky Mountain Region indicates that the population is still growing, but that there is still some reason for caution. Eggshell thicknesses continue to average less than "normal," and some drastically thin eggs are still found. Even so, the peregrine falcon may soon be down-listed to threatened or even taken off the endangered species list altogether.

A final objective of the program will be to develop a long-term plan to monitor peregrine populations in the Rocky Mountain Region in order to detect future population declines or contamination of the peregrines' environment. Early warning of a decline may allow us to detect and prevent a repeat of the past population crash.

Wolves Need Room to Roam!

By Layne Adams, Wildlife Research Biologist, Alaska Regional Office

For wolves in Gates of the Arctic National Park and Preserve, 8,000,000 acres are just not enough! A four year study of wolf population and subsistence harvest in and around the park has shown that individual wolves are dispersing in all directions at distances of up to 400 miles.

To gather data for the study, which began in 1987, park personnel captured and radio-collared 51 wolves and monitored them to gain insight into their habits. The collared wolves belonged to 13 to 16 packs, which allowed tracking of approximately 115 individuals in any given year. To gather further information on harvest of wolves, researchers spent time in the village of Anaktuvuk Pass talking to wolf hunters and trappers and enlisted the help of a village elder to purchase wolf carcasses and record the harvest over the winter.

The data gathered showed that dispersal has removed more radio-collared wolves from the study than any other type of loss. To date, seven wolves are known to have dispersed. Another eight missing wolves are probably dispersers; failure of radio-collars is extremely rare, and these wolves were young adults and disappeared during the spring when the hunting/trapping season is closed and dispersals are likely. In addition to these 15 dispersers, 10 radioed wolves have been harvested by subsistence users and eight have died of natural causes, primarily killed by other wolves.

This dispersal is probably not a real loss to the wolf population. There is every reason to believe that wolves from other populations are joining the Gates population as well. As more and more radio-telemetry studies of wolves are conducted in Alaska, it is becoming apparent that dispersal is common and quite a bit of intermixing of local wolf populations occurs. One of the dispersing wolves from the Gates of the Arctic study was found in the northern Yukon Territories, where it had paired with a radio-collared female that was part of a study being conducted by the Yukon Department of Renewable Resources!

Park wolf populations in Alaska are really only political subdivisions of a much larger contiguous wolf population of about 6,000 wolves, and possibly as many as 30,000 wolves, in Canada. Dispersal such as that documented in the Gates study is a key to the long-term survival of northern wolf populations. Such movements regularly introduce new genetic material into local populations and allow repopulation of areas where wolf populations are reduced by disease or overharvest. As long as northern wolves are able to move freely throughout their range, the future of the population as a whole is relatively secure.

Isle Royale Wolf Population Still Down

By Robert J. Krumenaker, Natural Resource Management Specialist, Isle Royale National Park

Murph, otherwise known as Wolf 421, died just days before the monitoring team began the 33rd annual winter study in Isle Royale National Park in January 1991. The annual wolf population count will not be completed until spring, but early signs indicate that the population may be down to 12 animals. While three pups survived in one pack in 1990, the level of reproduction has not changed markedly from the low level that has prevailed during the late 1980s.

In a continued search for the causes of the decline, eight wolves have been trapped and radiocollared. Blood and other samples were taken from each captured animal and studied for disease and genetic data. Although the presence of canine parvovirus and Lyme Disease was documented, there are no strong indications that disease or food shortages constitute significant problems.

The genetic discoveries seem to bear out expected theories of small population genetics, but do not yet allow us to say genetics problems are the cause of the current population decline. National Park Service funded genetics analysis of over 100 gray wolves from all over North America (including the eight from Isle Royale) has shown that Isle Royale wolves are not genetically unique, although the mitochondrial DNA pattern found at Isle Royale is apparently an uncommon variety. (A mitochondrial DNA pattern is a genetic "marker" with little or no bearing

on fitness or phenotype.) In the approximately five or six generations since the population was founded (and isolated) in the late 1940s, the Isle Royale wolves have apparently lost approximately 50% of the genetic variability found in mainland animals. All eight wolves tested are as closely related as siblings or parent/child, which could be a possible explanation for the low levels of reproduction.

One of the most interesting discoveries uncovered in the past year is that all wolves from eastern North America and many from the central part of the continent, including the Isle Royale population, show mitochondrial DNA that is derived from coyotes, evidence of past interbreeding. Analysis of nuclear DNA (the better-known and more "influential" genetic material) shows no signs of coyote introgression. This indicates that these animals are essentially "pure" wolves despite the coyote markers.

While studies of the three major hypotheses for population decline continue (disease, food shortage, and genetics), a fourth hypothesis may play the most significant role in the wolves' future; random chance or poor demographics may doom this population even if other factors do not. With Murph's death, the death of another collared animal last year, and the failure of one radio transmitter, five wolves remain "on the air."

The Winged Mapleleaf Mussel Hangs on at St. Croix Riverway

By Victoria Mendiola Grant,
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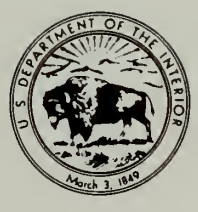
Once found throughout the upper Mississippi River system, the winged mapleleaf mussel has been reduced to a single population. The mussels now occur only along a five-mile reach of the St. Croix National Scenic Riverway, which flows along the border of Minnesota and Wisconsin.

During parkwide surveys of the freshwater mussel fauna in 1986-88, researchers discovered this unique concentration of the mussel. Continued study of this population has shown that it has not reproduced during the last five years. As a result of this discovery, the winged mapleleaf mussel is presently proposed as a federally endangered species.

Why has the winged mapleleaf mussel survived only in St. Croix? Why is there no successful reproduction? The answers to these questions are not clear. The Minnesota and Wisconsin Departments of Natural Resources, the National Park Service, and the U.S. Fish and Wildlife Service are working together to develop a long-term research program designed to understand the situation and evaluate how best to protect the species. The program will focus on habitat evaluation, reproduction, artificial propagation, identification of host fish species, and water quality and quantity needs.

In addition to a lack of recruitment, the winged mapleleaf mussel population is also suffering from another threat: low water flows. Immediately upstream of the population is a hydroelectric dam, which operates under a peaking regime. Built in 1906, this dam presently has no minimum water flows established below the facility and has historically operated at zero flow during off-peak night periods from November through March. This lack of water flow over the beds of mussels became highly visible during recent drought conditions. Concerned about freezing and desiccation, managing agencies are pursuing regulatory action to maintain adequate flows. Long-term studies are scheduled to begin this year.

The aquatic flora and fauna of many park units remain unexplored, largely due to the focus on more easily accessible terrestrial resources. Our experience at St. Croix points toward the urgent need to explore the aquatic resources of parks in a timely manner and to protect the fragile, susceptible resources harbored there.



As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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